

**Measuring poverty in the EU:  
Investigating and improving empirical validity in  
deprivation scales of poverty**

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## **Abstract**

Non-monetary deprivation indicators are now widely used for studying and measuring poverty in Europe. However, despite their prevalence, the empirical performance of existing deprivation scales has rarely been examined. This thesis i) identifies possible conceptual problems of existing deprivation scales such as indexing, missing dimensions and threshold; ii) empirically assesses the extent of possible error in measurement related to these conceptual problems; and iii) offer an alternative way for constructing deprivation measures to mitigate the identified conceptual problems. The thesis consists of four stand-alone papers, accompanied by an overarching introduction and conclusion. The first three papers provide empirical evidence on the empirical consequences of the missing dimensions and threshold problems for the measurement and analysis of poverty, while the fourth paper exemplifies a concept-led multidimensional design that can reduce the error introduced by these conceptual problems. The analysis is generally held for 25 EU countries using European Survey of Income and Living Conditions (EU-SILC); only in the second paper, the analysis is done for the UK using British Household Panel Survey (BHPS).

## 1. What is the main puzzle?

In the last two decades, there have been significant changes in how poverty is measured. Long been the dominant approach, income poverty measures faced strong criticisms questioning their validity. Three main conceptual issues have been important (Sen, 1983, 1992, 1999; Mayer and Jencks, 1989; Ravallion, 1996; Edin and Lein, 1997; Nolan and Whelan, 2007; Berthoud and Bryan, 2011): i) indexing problem – certain non-monetary dimensions of poverty are hard to monetize and include into a single money-metric measure; ii) missing dimensions problem – households differ in their non-income resources and needs some of which are typically not accounted in conventional measures; iii) threshold problem – thresholds are generally set without a solid theoretical ground due to a referencing problem.<sup>1</sup>

Given these critiques, a wide agreement has been reached on the need to broadening the analysis of poverty with some non-monetary indicators (Grusky and Kanbur, 2006; Jenkins and Micklewright, 2007; Kakwani and Silber, 2008a; Ravallion, 2016; Atkinson, 2017). Consequently, a significant amount of effort has been put in advancing new methodologies for constructing measures based on non-monetary deprivation indicators (see comprehensive edited volumes of Pantazis et al., 2006; Jenkins and Micklewright, 2007; Kakwani and Silber, 2008b; Betti and Lemmi, 2014). One strand of this literature is focused on constructing deprivation scales to measure poverty in the EU defined within Townsend's relative deprivation framework.<sup>2</sup> These deprivation scales combine different

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<sup>1</sup> Despite this stylized presentation of these three problems, there are clearly interactions among them. For example, threshold problem is interlinked to the lack of comparability across households and inability to account for non-monetary dimensions.

<sup>2</sup> See for axiomatic approach Tsui (2002), Bourguignon and Chakravarty (2003); for welfare approach Atkinson (2003), Araar and Duclos (2006); for fuzzy set approach Lemmi and Betti (2006); for latent variable approach, Kuklys (2005), Asselin (2009), Krishnakumar and Nagar (2008), and Tomlinson et al. (2008); for Alkire-Foster approach Alkire and Santos, (2013).

types of deprivations related to food, fuel, housing facilities, financial strain and social activities into a single measure, and are now used as supplementary (Atkinson et al., 2017), complementary (Maître et al., 2013) or alternative (Lansley and Mack, 2015) to income poverty measures.

In theory, such deprivation scales can improve on the indexing, missing dimensions and threshold problems. Regarding indexing problem, deprivation indicators can be employed as multiple non-monetary metrics as well as aggregated into a single composite index; yet, related challenges are to identify relevant dimensions and indicators, design reliable scales and set relative weights for each dimension.<sup>3</sup> Regarding missing dimensions problem, given that deprivation items directly evaluates unmet needs due to a lack of resources, they capture the variance across households in needs and resources yet only when each relevant need is included into the measures. Regarding threshold problem, multiple thresholds can be specified in a multidimensional space which is useful in making the value judgements apparent at each level and also minimizes the measurement error caused by a single threshold; still, specified thresholds should be backed both theoretically and empirically.

In practice, however, existing deprivation scales might be facing similar validity problems. Recent critiques point out a break between concepts and measures, and thus an inconsistency between who is defined and measured as poor. For example, Nolan and Whelan (2011) argue that despite the influential concepts in multidimensional approach, “the linkage from concept through to application has often been weak and implementation rather ad hoc”. Ravallion (2011) claims that the design of

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<sup>3</sup> In the case of a single composite index, the choice of functional form and aggregation method also has important empirical consequences on the results (Chiappero-Martinetti and Von Jacobi, 2012).

multidimensional measures of poverty is usually data-driven and rarely rooted in a prevailing theory or grounded in robust methodological assumptions. These “rarely justified or critically scrutinized” methodological assumptions (Chiappero-Martinetti and von Jacobi, 2012), or theoretically limited approaches might yet be directly consequential for the accuracy of measurement. Therefore, despite their potential to mitigate possible measurement problems, weak methodological or theoretical base of deprivation scales might still induce error in measurement.

Nevertheless, despite now the overwhelming literature on the methodologies of poverty measurement, there is little effort on to empirically evaluate the performances of proposed measures. Existing validity evaluations are usually undertaken primarily to justify the merits and properties of newly proposed measures. Yet, validity evaluations are also performance assessments, useful for identifying areas of improvement. Due to a lack of such performance assessments, there is not much evidence and discussion on the *extent* and *sources* of error in the literature (see also Atkinson, 2017).<sup>4</sup> As a result, the empirical evidence is limited on to what extent the proposed measures reach their main aim of identifying people in poverty.<sup>5</sup>

This thesis focuses on error and validity in deprivation scales. In this context, two main questions are asked: i) do (and to what extent) possible conceptual or methodological problems in deprivation scales induce error in measurement? If so, ii) what can be the alternative ways, both conceptually and methodologically, to improve the design of

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<sup>4</sup> Indeed, one of the main recommendations of the Atkinson Commission relevant for both income and non-monetary poverty measures is the evaluation of the extent and sources of non-sampling error, for example those introduced by the process of determining poverty lines (Atkinson, 2017).

<sup>5</sup> In general, the primary aim of poverty measures is identifying individuals and groups in poverty. After identifying who is poor, one can assess the extent of poverty in a country and compare cross-nationally, monitor the changes in poverty rates over time, assess the causes and consequences of poverty and relevant policy responses to it. Therefore, identification of poverty is the prime objective and also essential for reaching other objectives of poverty measurement.

deprivation scales? These questions are addressed in four empirical papers, where the first three papers focuses on the first question and provides empirical evidence on the extent and sources of measurement error in deprivation scales, and the fourth paper deals with the second question and suggests an alternative way to construct a deprivation measure of poverty that can mitigate the identified problems.

The analysis is concentrated mainly on three existing deprivation scales (see Table 1).

**Table 1: The deprivation scales analysed in this thesis**

<b>Guio 2009</b>	<b>Guio et al. 2016</b>	<b>Whelan &amp; Maitre, 2012</b>
Ability to afford	Ability to afford	Ability to afford
<ol style="list-style-type: none"> <li>1. not having arrears for rent, mortgage or utility bills;</li> <li>2. to keep their home adequately warm;</li> <li>3. to face unexpected expenses;</li> <li>4. to eat meat or proteins regularly;</li> <li>5. to go on holiday;</li> <li>6. a TV</li> <li>7. a washing machine</li> <li>8. a car</li> <li>9. a telephone</li> </ol>	<ol style="list-style-type: none"> <li>1. not having arrears for rent, mortgage or utility bills;</li> <li>2. to keep their home adequately warm;</li> <li>3. to face unexpected expenses;</li> <li>4. to eat meat or proteins regularly;</li> <li>5. to go on holiday;</li> <li>6. a car;</li> <li>7. PC &amp; internet</li> <li>8. replace worn-out furniture</li> <li>9. some new clothes</li> <li>10. two pairs of shoes</li> <li>11. some money for oneself</li> <li>12. leisure activities</li> <li>13. getting together with friends/family for a drink/meal monthly</li> </ol>	<ol style="list-style-type: none"> <li>1. to keep their home adequately warm;</li> <li>2. to eat meat or proteins regularly;</li> <li>3. replace worn-out furniture</li> <li>4. to go on holiday;</li> <li>5. some new clothes</li> <li>6. two pairs of shoes</li> <li>7. some money for oneself</li> <li>8. leisure activities</li> <li>9. getting together with friends/family for a drink/meal monthly</li> </ol>
<b>Thresholds:</b>		
3+: Material deprivation (MD) 4+: Severe material deprivation	5+: Material deprivation (MD) 7+: Severe material deprivation (SMD)	3+: Material deprivation (MD)
<b>Approach:</b>		
Consensual approach Consistent poverty approach	Consensual approach Consistent poverty approach	Consistent poverty approach

The first is the 9-item scale proposed by Guio (2009) which is used as part of the EU 2020 poverty target measure used to monitor the objective of lifting 20 million people out of poverty or social exclusion by 2020. The second is the 13-item scale proposed by Guio et al. (2016) as an update to the 9-item scale using a wider set of items collected in

2009 EU-SILC material deprivation module. The third is the 9-item scale proposed by Whelan and Maître (2012) which is extensively used by the authors for analyzing deprivation and poverty in the EU. The main data source is the EU SILC 2009 wave which includes a special module on material deprivation. In addition, in Paper 2, the British Household Panel Survey is used given the longitudinal nature of the analyses.

In this introductory chapter, the analytical framework used for analyzing error and validity in poverty measurement is described; the terminology and conceptual roots of deprivation scales are clarified; the design and uses of the employed deprivation scales are elaborated; and lastly, the four articles are summarized.

## **2. Error and validity in poverty measurement**

Measuring poverty includes multiple steps in translating the reality of poverty into an operational measure. In principal, one starts with a concept that represents a specific understanding of the reality of poverty. The concept is useful to identify the domain and informational space. An elaborate theoretical definition of the concept is necessary to separate poverty from other phenomena (e.g. well-being), specifies its distinct meaning and its dimensions. If a concept is not clearly defined, the meaning of poverty might vary depending on the measurement operations (e.g. available data, method of measurement etc.). Yet, despite giving a distinct characterization of the phenomenon, theoretical definitions still operate at a fairly abstract level. Operational definition is the step where the theoretical construct earns a more concrete meaning in a specific study in relation to observable indicators. An operational definition of poverty describes the process of actual measurement by elaborating on the instruments (e.g. indicators, scales or indices) and threshold(s) separating poverty from non-poverty.

Given this framework, error in measurement can occur in different steps – either in conceptualization or operationalization. In that respect, two different types of validity can be defined. The first is the *theoretical validity*, which concerns whether the “reality” of poverty is accurately translated into a specified concept, therefore involves a conceptual debate regarding the ontological and epistemological positions on what poverty actually means. The second is the *empirical validity*, which regards the performance of the operationalization step, and assesses whether *a priori* specified concept is adequately translated into a measure. The first regards the performance of a theoretical definition; the second regards the performance of an empirical definition.

The focus in this study is on the empirical validity of existing deprivation scales, hence on the systematic error that occurs when concepts are not fully reflected by the measures due to some conceptual design problems such as indexing, missing dimensions and thresholds. Therefore, the analysis investigates the link between concept (theoretical definition) and measure (operational definition). Accordingly, the next section elaborates on the conceptual roots of deprivation scales, which followed by the description of deprivation scales used in this study, and hypotheses on the possible sources of error in these deprivation scales given the inconsistencies between their theoretical and operational definitions.

Yet prior to this, it is important to distinguish between two types of empirical validity (or two different ways to assess empirical validity) used in this thesis. The first is *relative validity*, evaluating the validity of measures relative to the validity of other existing measures. As reviewed in Paper 1, most of the literature provides empirical evidence only on the relative validity of deprivation scales. Such relative examinations focus on construct validation and examines to what extent proposed vs. existing scale behaves in

the way that we *a priori* expect it to be on the basis of a relevant theoretical framework. These theoretical expectations can be defined, for example, based on the determinants or consequences of the concept of interest. In Paper 3, threshold problem is examined against the theoretically derived expectations on the determinants of deprivation.

The second is *absolute validity*, evaluating Type I and II errors in measurement. Type I error refers to the cases wrongly identified as in poverty, while Type II indicates the poverty cases missed by a measure. Such absolute examinations regard criterion validity and assess the level of accuracy in measurement. However, in such examinations, the main difficult is finding the criterion or yardstick for poverty. In Paper 1 a partial criterion variable, in Paper 2 a subjective criterion variable are used to examine Type II error. In both cases, a significant part of the analysis is devoted to evaluate the robustness of criterion variables and rule out possible bias incorporated in the analysis due to the impartial nature of criterion variables.

### **3. Conceptual framework: deprivation and poverty in Townsendian framework**

Most of the poverty research in Europe is conceptually rooted in Townsend's influential formulation of poverty as relative deprivation (see Townsend, 1962, 1979, 1987, 1993). According to this framework, "people are relatively deprived if they cannot obtain, at all or sufficiently, the conditions of life – that is, the diets, amenities, standards and services – which allow them to play the roles, participate in the relationships and follow the customary behavior which is expected of them by virtue of membership of society (Townsend, 1993:36)".

Three parts of this definition are important to emphasize. Deprivation is by definition *relative* as it refers to a disadvantage relative to standards of a society, hence relative

deprivation and deprivation can be used interchangeably. Deprivation refers to the *conditions of life* and not to subjective feelings of deprivation or economic resources. Deprivation is defined as an *inability* to obtain the conditions of life as it is attributable to constraints rather than preferences or choice – there might be different constraints such as limited economic resources, geographical distance, discrimination and ill-health, and only those relating to economic resource constraints regard poverty (*enforced criterion*).

Therefore, in this framework, Townsend makes a clear distinction and a link between poverty and relative deprivation (or deprivation). People are defined to be in poverty when “their resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities (Townsend, 1979:31)”. Poverty is primarily about the lack of resources, while deprivation is about the conditions of life. The theory is that after a certain level of income (or resources), which is purported as a poverty line, deprivation increases disproportionate to the decreases in income. “Thus while people experiencing some forms of deprivation may not all have low income, people experiencing multiple or single but very severe forms of deprivation are in almost every instance likely to have very little income and little or no other resources (Townsend:1987:131)“.

Townsend identifies different forms of deprivation as dietary, clothing, fuel, household facilities, housing conditions and amenities, conditions at work, health, educational, environmental, family, recreational and social. These deprivations represent sub-groups of the two main types of deprivation, namely material and social deprivation (Townsend, 1987:127). *Material deprivation* is about the “possession of material goods of modern life or the immediately surrounding material facilities or amenities”. *Social deprivation* is about not having “access to ordinary social customs, activities and relationships”.

Yet, the concept of material deprivation is subsequently altered partly depending on the available data and used as a pragmatic tool for constructing policy instruments. For example, Guio (2009) defines material deprivation as the enforced lack of a combination of items depicting material living conditions, such as housing conditions, possession of durables and capacity to afford basic requirements. Such operational definition reflects the content of the deprivation items selected based on factor analysis; indeed, Nolan and Whelan (1996; 2011) name a similar set of items as basic consumption or current life-style deprivation. Guio et al. (2016) emphasize that their material deprivation index includes items that covers material as well as social deprivation as defined by Townsend (1987). Therefore, the new concept of material deprivation represents a state of generalized deprivation subsuming both material and social types of deprivation determined mainly by available data.

Nevertheless, the conceptual roots of these recently proposed deprivation scales (e.g. Guio, 2009; Nolan and Whelan, 2011; Whelan and Maitre, 2012; Guio et al. 2016) significantly differ from each other, as well as from Townsend's original theory. Two distinct conceptual approaches can be identified.

The first is the consensual approach, originally proposed by Mack and Lansley (1985) based on a fundamental conceptual critique of Townsend, which applied and advanced by Halleröd (1994; 1996), Gordon (2000; 2006), Van den Bosch (2001), Halleröd et al. (2006), Guio (2009) and Guio et al. (2016). In this approach, poverty is defined as an exclusion from minimally accepted way of life, where such exclusion is viewed in terms of an enforced lack of socially perceived necessities. "This means that the 'necessities' of life are identified by public opinion and not by, on the one hand, the views of experts or, on the other hand, the norms of behaviour per se (Mack and Lansley, 1985: 45)".

Such definition is aligned with those adopted by European Commission in 1985, but should be contrasted with Townsend's approach, where the focus is not on socially accepted standards, but on a certain norm or ordinary living.<sup>6</sup> Mack and Lansley claim that a focus on norms and ordinary living patterns might be needed to study distributional justice, but for poverty an acceptable minimum way of life must be specified. Also, while Townsend's concept of poverty is primarily based on resources, Mack and Lansley's concept of poverty is based on conditions of life (unmet needs).

The second is the consistent poverty approach, suggested by Ringen (1985; 1988) based on an interpretation of Townsend's definition of poverty, which applied *inter alia* by Nolan and Whelan (1996; 2010; 2011), Whelan and Maitre (2012) and Maitre et al. (2013). In this approach, poverty is defined as exclusion from society due to inadequate resources. This notion of exclusion is closely related to the Townsend's understanding of inability to participate in ordinary living patterns. Yet an important difference is that, for Townsend, poverty is primarily about resources, while for Ringen, poverty is primarily about a low consumption standard (or conditions of life). Still, in Ringen's approach, poverty is considered to be manifested by "the accumulation of deprivation both in resources and in a way of life (Ringen, 1985: 105)". Therefore, the focus is on "enforced and generalized deprivation rather than on deprivation that is attributable to factors other than lack of resources, or deprivation that is enforced but only for specific areas of life (Whelan and Maitre, 2012:491)".

The next section details the design and different uses of deprivation scales related to these two approaches before describing possible sources of error in these scales.

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<sup>6</sup> This is because Townsend based his concept of poverty on an "objective" understanding of individual needs (externally observable and demonstrable), while Mack and Lansley view needs as socially constructed and define poverty in relation to a socially acknowledged minimum.

#### 4. The design and different uses of deprivation scales

Grounded in Townsend's conceptual framework, various deprivation scales are recently proposed and used in the EU context. These include scales proposed by Mack and Lansley (1985; 2015), Nolan and Whelan (1996; 2011), Gordon (2006), Guio (2009), Whelan and Maitre (2012), and Guio et al. (2016). The analysis in this thesis focuses on the three most recent EU deprivation scales by Guio (2009), Guio et al. (2016) and Whelan and Maitre (2012) (see Table 1). Also, the scale proposed by Mack and Lansley (1985; 2015) is discussed here as an alternative way to constructing deprivation scales.

These deprivation scales have certain common design features. They are all unidimensional which collapse different types of deprivation into a single scale. They are constructed based on a counting approach, where total deprivation score is the count of deprived items from an *a priori* specified list of items, and the deprived (vs. non-deprived) is defined based on arbitrarily selected threshold on the deprivation score (e.g. being deprived of two or more items). And, often a higher threshold is set to analyze more severe forms of material deprivation.

Despite their similar design, the use of deprivation scales varies depending on their conceptual reference. For example, while Townsend's aim of using deprivation items was to devise an income poverty threshold, more recent deprivation scales are used as supplementary, complementary or alternative to income poverty measures.

Mack and Lansley (1985; 2015) used their deprivation scale as an *alternative* to the income poverty measures. The items are selected based on a consensual criterion. Using data from an attitudinal survey (e.g. Breadline Britain and PSE surveys), an item is included into the scale if it is viewed by at least half of the population as necessary for

having a minimally accepted living standard in the UK at the time. For example, in 2012 survey, of the 46 items asked about for adults, 25 were found to be essential necessity by a majority of people. Then, Mack and Lansley (2015) define people in poverty as those who have three or more (enforced) deprived items from that list. Lastly, Mack and Lansley make some posterior adjustments including the one for high incomes which is mainly excluding those people who have high incomes (e.g. highest income decile) from the identified poverty group.

Whelan and Maitre (2012) used their deprivation scale as *complementary* to an income poverty measure. Selected based on an exploratory factor analysis which is applied to a wider set of items identified based on expert opinion (given their theoretical relevance to poverty), nine binary deprivation items are used for their deprivation scale with a threshold of two (3+). This deprivation scale is suggested to be used alongside a relative income poverty measure (Whelan et al. 2013). Therefore, people in poverty are defined as those who experience both deprivation and income poverty (*intersection method*).

Guio et al. (2016) used their deprivation scale as *supplementary* to an income poverty measure. Selected again based on a exploratory factor or cluster analysis which applied to a wider set of items identified based on consensual as well as expert opinion (given various analysis held at the item level), thirteen deprivation items comprises their scale. Guio et al. (2016)'s measure can be considered a hybrid between Townsend and Mack and Lansley using both consensual and expert criteria. This new scale is proposed as an update to the previous 9-item scale used as a part of the EU 2020 poverty target measure. In this headline poverty indicator, the people in at risk of poverty or social exclusion are defined as those experiencing material deprivation, income poverty or low work intensity (*union method*).

## 5. Possible sources of error in deprivation scales

As argued above, different uses of deprivation scales arise out of their distinct conceptual reference. If the link between concepts and measures are not strong, error in measurement can arise due to an inconsistency between who is theoretically defined and who is empirically measured as in poverty. Then, three conceptual problems in existing deprivation scales might potentially be the source of measurement error.

The first is *indexing or more specifically the data-driven specification*. Although relevant deprivation items are primarily selected based on theory (e.g. consensual and expert criterion), deprivation scales are constructed based on data-driven methods (exploratory factorial techniques). Therefore, the specification of resulted scales is ultimately data-driven.<sup>7</sup> However, the development of data on deprivation items (e.g. EU-SILC) has been fairly arbitrary, “different countries learning from each other while having their own preoccupations” (Nolan and Whelan 2011:15). As a result, the available items do not represent a coherent conceptual framework, and seem to be selected from a wider set of items without any systematic procedure. Therefore, the derived measures are not

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<sup>7</sup> Deprivation scales are usually constructed based on exploratory factor analysis (or similar techniques such as multiple correspondence analysis, multidimensional scaling), a method employed to group items based on their covariance structure. The scales are constructed based on the derived factors (or dimensions) which do not have a direct conceptual meaning but rather represent different scales of poverty. The ultimate scales then is defined either by combining different factors together or by choosing one of the factors given its stronger associations to income and financial stress. For example, Guio and Maquet (2007) and Guio (2009) identify three dimensions, economic strain, durables and housing, and combines first two dimensions given their high correlation to each other and high associations to income. Based on a wider set of deprivation items collected in 2009 deprivation module, Guio et al. (2016) identify four dimensions, namely material deprivation, basic amenities, local environment and accessibility. Guio et al. then construct their scale based on items from the first dimension. On the other hand, using the same set of items from the module, Whelan and Maitre (2012) identifies six dimensions, namely basic, consumption, household facilities, health, neighbourhood and access to public facilities. Whelan and Maitre construct their index based on the first dimension (basic deprivation) given its relatively higher correlations (compared to other dimensions) with log equivalized income and economic stress. The material deprivation dimension identified by Guio et al. (2016) includes the items from basic, consumption and household facilities dimensions identified by Whelan and Maitre (2012).

directly driven by the concepts but by a data which does not reflect a coherent understanding of poverty as relative deprivation. As a result, one might expect the link between concept and measure to be weak.

The second is *missing dimensions*. Deprivation scales typically include a limited set of items to represent a much broader concept of poverty (except those of Mack and Lansley). For example, they include items related to the needs in food, fuel, clothing and certain other comfort goods and social activities. Yet, they exclude needs related to health care, child care, social care and education which represent areas of life generally considered essential for leading a decent life and hence can be considered as part of the concept of poverty defined in Townsendian terms. A part of this problem is related to the lack of available data – available deprivation items in e.g. EU-SILC are not adequate to cover the whole concept of poverty as relative deprivation (Maitre et al. 2013:5; Hick, 2014). As a result, people with experiences of poverty related to missing dimensions might be missed by the existing deprivation scales. Yet, it is generally assumed a few deprivation indicators representing “key aspects of living” can be adequate to identify people in poverty (Marlier et al., 2007). As put by Nolan and Whelan (2007), this is an empirical matter; however, recent multidimensional applications have shown that accounting for the joint distribution of all dimensions is not only useful for understanding the varying patterns of distinct dimensions but also determines who is identified as “poor” (Whelan et al., 2014; Alkire et al., 2015; Hick, 2015). Therefore, including items only for some aspects of living might be another source of measurement error, causing a failure to identify some people in poverty (Type II error).

The third is *threshold problem or more specifically the use of non-zero thresholds in a unidimensional scale (and the neglect of dimensionality)*. The existing deprivation

measures are designed as unidimensional scales which collapse and evaluate different types of poverty in a single measure. Then the applied thresholds are often selected relatively arbitrarily. For example, using similar deprivation scales, Mack and Lansley and Gordon identify different thresholds. As of relative income poverty measures, thresholds used for the deprivation scales do not have a solid theoretical ground. Certain theoretical justifications claimed for the selected thresholds either have some conceptual issues or could not be supported empirically.<sup>8</sup> Moreover, in a unidimensional scale, using an *ad hoc* non-zero threshold might exclude some people who experience poverty due to deprivation in only one dimension. Therefore, the use of non-zero threshold in a unidimensional scale might be another source of measurement error.

In this context, the four papers are aimed at empirically testing the measurement error arising from these three conceptual problems in deprivation scales. However, despite this stylized presentation, these three conceptual problems are not totally independent from each other. For instance, the idea and specification of threshold is linked to the content of the measures; or the number and type of dimensions are directly relevant to the specification of the scales. Therefore, these three conceptual problems cannot be considered separately and where possible should be evaluated together.

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<sup>8</sup> In general, two theoretical justifications are given for deprivation thresholds. The first is the Townsend's theory about a breaking point at the level of income below which deprivation increases disproportionate to the decreases in resources. For example, to identify a deprivation threshold Gordon (2006) uses an ANAVO analysis that maximizes the difference between poor and non-poor group based on equivalized income. However, despite its theoretical plausibility, such inflexion point has not been well-established empirically. Also another problem is that income is only a limited indicator of resources against needs. The second is the argument used by Mack and Lansley (1985) and Nolan and Whelan (1996) among others. According to this argument, deprivation does not necessarily result in poverty because low levels of deprivation might not force people to change their life styles. In other words, deprivation of only one item might not be considered as poverty because it might not affect individual's way of living (Mack and Lansley, 1985: 41). On the other hand, as Hallerod (1994) argues, if selected items are identified as necessities of life, lack of even one item might be considered as living in poverty.

In line with this consideration, although each paper in this thesis focuses specifically on one of these problems, they also include certain robustness checks to control the effect of other conceptual problems. For example, Paper 1 and Paper 2 focus specifically on the missing dimensions problem in deprivation scales, but the sensitivity of the results to different thresholds and index specifications are also tested. Paper 3 deals with the threshold problem yet considers different scales with a shorter or longer list of items. Yet, while the missing dimensions and threshold problems are possible to examine empirically based on existing deprivation scales, the indexing problem can only be examined empirically by comparing the existing deprivation scales to a new concept-led measure. Therefore, while the main aim of Paper 4 is to propose a new measure, the analysis applied in this paper can be seen as a test for the indexing problem by comparing the proposed concept-led measure to the existing measures.

## **6. The structure of this thesis – brief description of the four papers**

The thesis includes four empirical papers. The first three papers focus on empirically examining the possible measurement error due to missing dimensions and threshold problems – i.e. address the first research question of the thesis. The fourth paper, based on the findings of the first three papers, offers a new multidimensional deprivation measure of poverty for the EU that can mitigate the problems identified earlier – i.e. addresses the second research question of the thesis.

*Paper 1* examines the missing dimensions problem in deprivation scales using a partial criterion variable. The idea is to focus on a specific type of deprivation that is not accounted in existing deprivation scales despite being defined as a substitutive part of the poverty experience, and examine to what extent existing deprivation scales captures such deprivation. For example, this first paper focuses on health care access dimension

and considers having an unmet health care need due to affordability problems as a case of poverty. Therefore, such deprivation is considered as a partial criterion variable, which is a standard that can qualify *some* individuals as poor. Then those who have such deprivation but not identified by a deprivation scale show Type II error. Yet, for such error to qualify a significant empirical validity problem, the error should be systematic, for example due to a problem in the design of deprivation scales such as missing dimensions. In this context, the analysis includes theoretically and empirically justifying the selected variable as a partial criterion variable for poverty; examining the mismatch between the partial criterion variable and deprivation scales; and exploring the mechanisms through which the omission of health care access dimension translates into measurement error. The analysis uses EU SILC 2009 and is applied in general to the whole EU sample. This paper is published in *Social Indicators Research*.

*Paper 2* evaluates the missing dimensions problem in deprivation scales using a self-reported financial adequacy measure as a proxy for poverty. The idea is to i) test whether having needs in dimensions that are not included in deprivation scales such as health care, child care, social care and education affects poverty status even after controlling for deprivation status, and if so, ii) explain the mechanism through which missing dimensions affect poverty status. However, due to using a subjective criterion variable, various endogeneity problems might arise (e.g. scale heterogeneity, personality traits, state dependence, anticipation effect and psychological negativity). By using a dynamic correlated random-effect model, the aim is to control for such biases and provide empirical evidence on the importance of missing dimensions for the measurement of poverty. The analysis uses British Household Panel Survey data from 1999-2008. This paper is now under review for *Journal of European Social Policy*.

*Paper 3* evaluates the threshold problem in deprivations scales by examining the determinants of deprivation under different thresholds. The paper is structured based on one specific hypothesis that gives a conceptual basis on a deprivation threshold, which is that zero deprivation is qualitatively distinct to counts (one, two ... nine). In other words, those with zero deprivation have significantly distinct risk profiles than those with at least one deprivation. Therefore, zero can be used as a natural threshold for distinguishing deprived from non-deprived. I examine this hypothesis by i) comparing the risk profiles of each deprivation group considering income, social class, education, health and other relevant factors; ii) applying and comparing multiple count models to see whether the models that appropriately account distinct zeros fits the data better than other models; and iii) examining to what extent using a threshold of zero rather than a non-zero threshold (e.g. 2+) reveals expected determinants and social class gradient on the risk and the level of deprivation. The analysis is done separately for 25 EU countries using EU SILC 2009. This paper received 'revise and resubmit' from *European Sociological Review*.

*Paper 4* proposes a multidimensional deprivation measure of poverty for the EU. The aim is to mitigate the error identified in previous articles by using an appropriate design. The measure has four distinct features. First, it is a concept-led measure where the measurement design is determined based on the definition of poverty. For doing this, a substantial part of the analysis deals with conceptually deriving the dimensions of poverty. Secondly, the measure is more comprehensive compared to its existing counterparts including dimensions such as needs related to health and education. Thirdly, it is a multidimensional measure, where each dimension is evaluated separately with a relevant scale. Lastly, the proposed measure is adjusted using dual criteria of

income poverty and self-assessed financial strain to correct for error due to possible data problems. Therefore, a detailed discussion of the data problems in deprivation items is also included in this paper. Also, the distribution of the proposed measure across EU countries and the performance of the proposed measure vis-à-vis EU 2020 poverty target measure in identifying the people in poverty are also examined.

In sum, through these four papers, I mainly envisage contributing to the literature by providing empirical evidence on the extent of error due to missing dimensions and threshold problems; and by proposing an alternative method of constructing a deprivation measure of poverty that can improve on the three identified problems.

The remainder of the thesis structures in the following way. The next four sections consist of four empirical papers that comprise the main body of the dissertation. Given the self-contained nature of the four papers, references, appendices and supplementary materials are given at the end of each paper, respectively, and figures and tables are numbered individually for each paper. The four papers are followed by a concluding chapter which summarises the main findings of the four papers, discusses their contribution to the relevant literature, and highlights key policy implications. As part of the conclusion, I will also outline an agenda for future research that builds on the findings of this thesis.

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**Paper 1:**

**Missing the unhealthy? Examining empirical validity of existing deprivation scales using a partial criterion variable**

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## **Abstract**

This study investigates the empirical validity of the existing deprivation scales using a partial criterion variable. This alternative approach helps to assess the extent and sources of error in measurement (Type I and II errors). For example, this study conceptually and empirically justifies “unmet health care need due to inadequate resources” (UHCNIR) as a partial criterion variable for poverty. A simple mismatch analysis, then, identifies a sizable group, around 1% of the adult EU population, missed by the existing deprivation scales despite being in UHCNIR. A majority of this 1% experiences not only UHCNIR but also multiple other deprivations, commonly reports having some difficulties making ends meet, and prevalently has a disability or a chronic health problem. Further analysis investigating the source of such error points out a missing dimensions problem – deprivation scales miss specifically those “unhealthy poor” as these measures do not account for varying needs and costs of health care. Therefore, the main methodological assumption of the existing deprivation scales, identifying the people in poverty with only a limited set of key deprivation indicators, is not supported by this empirical analysis.

**Keywords:** measurement validity; unmet need for healthcare; poverty measurement with multiple deprivation indicators; missing dimensions problem; disability and chronic health problems; conversion factors; multidimensional measurement of poverty

## 1. Introduction

There is now widespread agreement on the need to broaden the analysis of poverty beyond income-based assessments. Employing different methods, various poverty measures using multiple deprivation indicators have recently been proposed (*inter alia* Jenkins and Micklewright, 2007; Kakwani and Silber, 2008; Alkire and Santos, 2013). Deprivation scales are one example of such measures, now widely used to assess poverty in the EU. 9-item scale proposed by Guio (2009) is one formal measure to monitor the EU poverty target of lifting at least 20 million people out of poverty by 2020. Similar measures for the EU are proposed by Nolan and Whelan (2011), Guio et al. (2016), and Whelan and Maître (2012).

The primary aim of these indices is to identify individuals and groups in poverty. Yet recent critiques on the “multidimensional” approach point at possible validity problems - a break between concepts and measures, and thus an inconsistency between who is defined and measured as “poor”. Despite the influential concepts in the multidimensional approach, Nolan and Whelan (2011:5) argue, “the linkage from concept through to application has often been weak and implementation rather *ad hoc*”. This separation of concepts from measures is partly due to data limitations but also reflects the level of theoretical and methodological advancement in the multidimensional approach. Ravallion (2011) claims that the design of multidimensional indices of poverty is usually data-driven and rarely rooted in a prevailing theory or grounded in robust methodological assumptions. These “rarely justified or critically scrutinized” methodological assumptions may however affect the accuracy of measurement (Chiappero-Martinetti and von Jacobi, 2012:92).

The aim here is to assess whether such validity problems are relevant to the existing deprivation scales, and, if so, why. The paper investigates these issues using the concept of *empirical validity*, which focuses on the performance of the operationalization step – whether a concept is adequately translated into a measure.<sup>9</sup>

The existing evidence on the empirical validity of deprivation scales is limited. Using only construct validation method, existing studies are always and necessarily relative – evaluating the validity of measures against the validity of other measures (*relative validity*). However, what is more essential to the study of empirical validity is the evidence on Type I and II errors (*absolute validity*), and the possible sources of such error.<sup>10</sup>

Such evidence can be explored using *partial* criterion variables. A partial criterion variable is a standard that can qualify *some* individuals as poor (or non-poor).<sup>11</sup> Despite focusing on a specific aspect of poverty, it is a sufficient criterion for poverty identification of certain groups (*partial criterion variable assumption*), hence can be used to identify some Type II errors. These Type II errors qualify as a significant validity problem if they i) reflect systematic misclassification of certain groups, and ii) arise due to a problem in the design of deprivation scales.

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<sup>9</sup> Empirical validity is different from theoretical validity. *Theoretical validity* assesses whether the “reality” of poverty is accurately translated into a specified concept, therefore involves a conceptual debate regarding the ontological and epistemological positions on what poverty actually means rather than how the concept is operationalized.

<sup>10</sup> Type I errors occur when a poverty measure identifies some people who are not actually in poverty. Type II errors arise when a poverty measure do not identify some people who are actually in poverty.

<sup>11</sup> The analysis here focuses on the partial criterion variables that can assess only Type II errors. So, the partial criterion variable identifies the poor individuals, and its mismatch with a poverty measure shows the people who are missed by the measure despite being poor. Some other partial criterion variables can also be used to assess Type I errors. Such a criterion variable needs to be a yardstick for the non-poverty experience, and its mismatch with a poverty measure would then show the people who are wrongly identified as in poverty by the poverty measure.

Based on the poverty definitions employed in relevant studies, “unmet health care need due to inadequate resources” (*abbreviated as UHCNIR hereafter*) is suggested here as a suitable partial criterion variable for poverty. If an individual cannot receive necessary health care because she/he cannot afford it, she/he might be considered as poor.<sup>12</sup> Existing evidence suggests that UHCNIR more likely identifies those with lower resources, and with a significant health problem (e.g. disability) (Koolman, 2007; Huber et al., 2008; Litwin and Sapir, 2009; Bremer, 2014). Moreover, deprivation scales might specifically miss these groups as they do not include relevant items, hence cannot adjust for varying needs and costs of health care.

Using UHCNIR as a partial criterion variable, the analysis therefore examines whether existing deprivation scales systematically miss those with lower resources and a disability or a chronic health problem; and, whether this is due to a structural problem in the design of deprivation scales. To examine the latter issue, deprivation scales are compared to two other poverty measures (income poverty; subjective income inadequacy) in their ability to estimate the criterion variable equally across health groups.

In the following sections, deprivation scales are described; relevant evidence on their empirical validity is briefly summarized; possible sources of error in deprivation scales are postulated; data and methodology are presented; and, UHCNIR is defined, and theoretically and empirically justified as a partial criterion variable for poverty. The article concludes with a discussion of the results and their implications on poverty measurement.

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<sup>12</sup> This assumption is conceptually and empirically examined in the following sections.

## 2. What are deprivation scales?

Deprivation scales are unidimensional measures constructed using multiple deprivation items primarily for improving the identification of poverty. The scales analyzed here are described in Table 1. Employing a typical set of items from the EU-SILC survey, deprivation scales differ in various aspects. This paper distinguishes two approaches: the *consistent poverty approach* and the *consensual approach*. Despite their common roots in the Townsendian framework, the two approaches employ different poverty definitions. Differences in definition then translate into differences in operationalization.

Conceptualized by Ringen (1985; 1988) based on an interpretation of Townsend's definition and applied *inter alia* by Nolan and Whelan (1996; 2011), the *consistent poverty approach* defines poverty as "exclusion from society due to inadequate resources". This concept of exclusion is closely related to the Townsend's notion of "inability to participate in ordinary living patterns". For operationalization, Nolan and Whelan (1996) focus on specifying what *manifests* these ordinary living patterns and identify related deprivation items based on some criteria derived from the definition and some practical policy considerations (*expert criterion*).

Originally developed by Mack and Lansley (1985) based on a fundamental conceptual critique of Townsend (1979), and applied and advanced *inter alia* by Gordon (2000; 2006) and Guio (2009), Guio et al. (2016), the *consensual approach* defines poverty as "exclusion from a minimally accepted way of life due to inadequate resources". For operationalization, Mack and Lansley (1985) identify what *constitutes* this minimum level of living, and apply an attitudinal survey to specify socially perceived necessities for having a minimally accepted way of living (*consensual criterion*).

**Table 1: Deprivation scales of poverty**

<b>Guio, 2009</b>	<b>Guio et al. 2016</b>	<b>Nolan &amp; Whelan, 2011</b>	<b>Whelan &amp; Maitre, 2012</b>
Ability to afford	Ability to afford	Ability to afford	Ability to afford
<ol style="list-style-type: none"> <li>1. not having arrears for rent, mortgage or utility bills;</li> <li>2. to keep their home adequately warm;</li> <li>3. to face unexpected expenses;</li> <li>4. to eat meat or proteins regularly;</li> <li>5. to go on holiday;</li> <li>6. a TV</li> <li>7. a washing machine</li> <li>8. a car</li> <li>9. a telephone</li> </ol>	<ol style="list-style-type: none"> <li>1. not having arrears for rent, mortgage or utility bills;</li> <li>2. to keep their home adequately warm;</li> <li>3. to face unexpected expenses;</li> <li>4. to eat meat or proteins regularly;</li> <li>5. to go on holiday;</li> <li>6. a car;</li> <li>7. PC &amp; internet</li> <li>8. replace worn-out furniture</li> <li>9. some new clothes</li> <li>10. two pairs of shoes</li> <li>11. some money for oneself</li> <li>12. leisure activities</li> <li>13. getting together with friends/family for a drink/meal monthly</li> </ol>	<ol style="list-style-type: none"> <li>1. To pay their rent, mortgage or utility bills;</li> <li>2. To keep their home adequately warm;</li> <li>3. To face unexpected expenses;</li> <li>4. To eat meat or proteins regularly;</li> <li>5. To go on holiday;</li> <li>6. A car;</li> <li>7. PC</li> </ol>	<ol style="list-style-type: none"> <li>1. to keep their home adequately warm;</li> <li>2. to eat meat or proteins regularly;</li> <li>3. replace worn-out furniture</li> <li>4. to go on holiday;</li> <li>5. some new clothes</li> <li>6. two pairs of shoes</li> <li>7. some money for oneself</li> <li>8. leisure activities</li> <li>9. getting together with friends/family for a drink/meal monthly</li> </ol>
<b>Thresholds:</b>			
3+: Material deprivation (MD) 4+: Severe material deprivation (SMD)	5+: Material deprivation (MD) 7+: Severe material deprivation (SMD)	2+: Material deprivation (MD) 3+: Severe material deprivation (SMD)	2+: Material deprivation (MD) 3+: Severe material deprivation(SMD)
<b>Operationalization</b>			
Consensual criterion Expert criterion	Consensual criterion Expert criterion	Expert criterion	Expert criterion
<b>vis-à-vis income poverty:</b>			
Union method Intersection method	Union method Intersection method	Intersection method	Intersection method
<b>Approach:</b>			
Consensual approach Consistent poverty approach	Consensual approach Consistent poverty approach	Consistent poverty approach	Consistent poverty approach

**Notes:** The older scales, Guio (2009) and Nolan and Whelan (2011), employ items from the main EU-SILC survey, while the updated versions, Guio et al. (2016) and Whelan and Maitre (2012), utilize the special module survey on material deprivation. The data on items such as clothes, shoes, leisure activities and spare money are collected in the special module and therefore does not exist for the older indices.

Another distinction between the two approaches relates to their use vis-à-vis income poverty measures. Deprivation scales from the consensual approach are sometimes used based on a *union method* – people in poverty are defined as those who experience either deprivation or income poverty; while the scales from the consistent poverty approach are usually used based on an *intersection method* – people in poverty are defined as those who experience both deprivation and income poverty.

In this framework, the scales proposed by Nolan and Whelan (2011) and Whelan and Maitre (2012) are readily distinguished as measures of consistent poverty approach. Nevertheless, the scales proposed by Guio (2009) and Guio et al. (2016) are hybrids, with items selected both by consensual and expert criterion. Despite reflecting a conceptual inconsistency, the hybrid nature of these scales means that both the union and the intersection methods may be used in their implementation (see e.g. Guio, 2009).

### *2.1. Existing evidence on the empirical validity of deprivation scales*

The literature provides limited evidence on the empirical validity of deprivation scales. Existing studies usually focus only on construct validation and present “relative” evidence based on correlations. These studies claim validity by relating the newly proposed scales to the existing poverty measures and comparing their ability to i) identify high poverty-risk groups (e.g. low social class, unemployed, lone parents) (Nolan and Whelan, 1996; Layte et al., 2001; Guio and Marlier, 2014); ii) correlate most highly with the variables that are a priori expected to be associated with poverty (e.g. financial stress, psychological distress, low life satisfaction, bad health and various other welfare outcomes) (Nolan and Whelan, 1996; 2011; Layte and Whelan, 2001; Halleröd and Larsson, 2008; Hick, 2014; 2015); iii) explain within and between country differences in variables such as financial stress (Whelan et al., 2001; Whelan and Maître, 2013); and

iv) produce poverty rates consistent with social class and welfare regimes profiles (Nolan and Whelan 2011). Yet even if a measure performs better in terms of relative validity, it might still suffer from significant error in terms of absolute validity.

## 2.2. *Possible sources of error in deprivation scales*

A measure lacks empirical validity when significant measurement error occurs. Measurement error can be systematic or random. The focus here is on the systematic error that occurs when the concepts are not fully reflected by the measures due to problems of design. Given limited data, certain conceptual or methodological assumptions made in the design of deprivation scales might be empirically unfounded and be the actual sources of systematic error. This problem might particularly be prevalent when the specification of deprivation scales is guided not by theory but by data.

In related studies, relevant deprivation items are usually selected based on theory, but actual scales are constructed based on data-driven methods (exploratory factorial techniques). Therefore, the specification of resulted scales is ultimately data-driven. Yet the development of these data on deprivation items, in ECHP or EU-SILC, has been fairly arbitrary, “different countries learning from each other while having their own preoccupations” (Nolan and Whelan 2011:15). The available deprivation items do not represent a coherent conceptual framework, nor they adequately cover the whole concept of poverty as exclusion from ordinary living patterns (Berthoud and Bryan, 2011; Maître et al., 2013:5; Hick, 2014). As a result, deprivation scales necessarily include only *some* key indicators but do not cover all different aspects of poverty.

The main methodological assumption of deprivation scales is that people in poverty can be identified using a few key deprivation items. But recent multidimensional applications

have shown that accounting for the joint distribution of all dimensions is not only useful for understanding the varying patterns of distinct dimensions but also a determinant of who is identified as “poor” (Whelan et al., 2014; Alkire et al., 2015; Hick, 2016). This raises concerns about the validity of the summary deprivation scales. If items relating to certain relevant need and deprivation structures are not included, a deprivation scale might fail to identify related cases of poverty – hence missing dimensions problem.

One such aspect of poverty that is not accounted in a typical deprivation scale is health. Extra costs of disability and the need for equalization across households with different health conditions have long been realized in the literature on income poverty (Mayer and Jencks, 1989; Sen, 1992; Zaidi and Burchardt, 2005; Morciano et al., 2015). The same equalization problem applies to deprivation scales as they do not include relevant items, thus cannot adjust for the differences in needs and costs of health care. Hence, deprivation scales might miss the poverty experiences regarding health care access.

This problem might be particularly prevalent given the unidimensional design of such measures. Deprivation scales typically include items from different types of poverty such as food, fuel, housing, durables and social activities. These different dimensions are combined into a single scale, and a threshold on the total number of deprived items is applied to distinguish poor from non-poor. Yet using a threshold in an unidimensional scale including different types of deprivations might not be adequate to capture a multidimensional phenomenon such as poverty. Especially when some dimensions such as health care access are not included into the measure, different need patterns might translate into different thresholds in a single scale. So, healthy and unhealthy groups might have, in reality, different thresholds for poverty in a single scale. The main aim here is to examine the impact of missing dimensions problem under different thresholds.

### **3. Data and methodology**

#### *3.1. Data*

This paper uses the 2009 wave of EU-SILC survey including a special module on material deprivation. The sample provides information on EU-25 countries. The unit of analysis is individual. Thus, information on deprivation collected at the household level is allocated to each household member. Given the information is collected only for adults, individuals aged below 16 are excluded. However, information on some deprivation items, health variables and more importantly UHCNIR are collected at the individual level, and only for the household reference person (HRP) in countries using administrative data such as Denmark, Finland, Netherlands, Sweden and Slovenia.

One way to deal with this problem is to allocate the HRP information to other household members, as adopted by Guio et al. (2016). This might be a good strategy for the deprivation items given the assumption of intra-household transfers. However, the same assumption might be harder to make for UHCNIR as the unmet need question includes individuals' own assessment of their health. Also, low levels of UHCNIR in these register countries do not provide much variance for the analysis. Therefore, these five countries (7% of the total sample) are excluded from the analysis. The conclusions for the overall EU seem to be unaffected by this exclusion as similar results are found with and without the HRPs' of these countries possibly because the overall sample size is high and the rates of UHCNIR in these countries are generally really low. In general, missing cases for the variables of interest is lower than 1%, hence excluded.<sup>13</sup> The final sample contains 350,408 individuals, represents a target population of adults (16+) in 21 EU countries.

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<sup>13</sup> There are yet further missing (8%-16%) for health indicators in some countries such as Czech Republic, the UK and Poland, which are excluded given the EU focus of analysis.

The construction of the criterion variable as well as other poverty measures used in the analysis is described in Table A1 in Appendix. Two variables are used to construct UHCNIR. The first one asks each adult individuals whether they have unmet needs for medical examination or treatment. If one answers yes, a follow-up question asks the specific reasons for this unmet need – is it because of waiting lists, too far to travel/no means of transportation, could not take time because of work, care for children (among other reasons), or is it actually because they could not afford to? The UHCNIR rate is calculated as the ratio of those “having unmet health care need because they could not afford to” to the total sample.

### *3.2. An alternative methodological approach to test empirical validity of deprivation scales*

In the existing literature, validity evaluations are often held using a construct validation method. As reviewed above, these studies typically examine whether their new scales vis-à-vis the existing poverty measures are more closely related to the variables that are a priori expected to be related (e.g. various welfare problems or risk groups). Yet, establishing absolute validity of a measure requires knowledge of both the number of people erroneously identified as being in poverty (Type I) and the number of people experiencing poverty who were missed by the measure (Type II). Also, existing validity evaluations are usually undertaken primarily to justify the merits and properties of newly proposed measures. Yet, validity evaluations are, in general, performance assessments, useful for identifying areas of improvement. However, there is not enough evidence and discussion on absolute validity and sources of error in the literature.

To provide evidence and facilitate such discussion on the absolute validity and sources of error, an alternative approach that can detect Type I and II errors is necessary. The

question to be explored is the following: whatever the type or form of poverty, are deprivation scales able to identify if it is a case of poverty? Different types or forms of poverty might include a set of dimensional deprivations or a set of item deprivations. Yet it might not be readily clear from the existing definitions which sets of deprivations imply a case of poverty. For example, how many and which combinations of deprivations can be held to define the poverty experience?

Given the difficulty of specifying *each* set of deprivations that entail a case of poverty, the goal here is to concentrate on a *specific* type of deprivation that is defined to be a component of the poverty experience, but not included in the deprivation scales. An indicator of such deprivation can be described as a partial criterion variable. Such criterion variable can benchmark certain cases of poverty. Then a simple mismatch analysis between deprivation scales and the criterion variable can be used to identify some Type II error related to a certain aspect of poverty.

One objection to that might be the insufficiency of one dichotomous variable to identify poverty. Individuals might not change their way of living due to a single deprivation by utilizing their savings or social support mechanisms (Mack and Lansley, 1985; Callan et al., 1993). This view rejects an understanding of poverty as a multi-component experience and thus looks for the evidence for multiple simultaneous deprivations. To investigate this and justify UHCNIR as a partial criterion variable, firstly, the theoretical and empirical relationships of UHCNIR and poverty are investigated; and secondly, the profiles of the people missed by the deprivation scales (despite being in UHCNIR) are examined using multiple other poverty measures, including a financial strain index proposed as a validity measure by Maitre et al. (2013).

Also, with the proposed criterion variable, only Type II error can be evaluated. The proposed criterion variable is partial, focusing on a specific aspect of poverty rather than the whole domain. So, while being deprived of the criterion variable indicates poverty, not being deprived of the criterion variable does not necessarily indicate non-poverty – individuals might be experiencing multiple deprivations other than the criterion variable.

The identified Type II error for a specific aspect of poverty does not readily amount to a significant measurement error. To qualify as a substantial empirical validity problem, the total Type II error should either result in significant over or under-estimation, or cause systematic misclassification of certain groups. Given its partial nature, the analysis here cannot examine the total error in poverty incidence. Still, a careful selection of the partial criterion variable can help to identify some systematic error due to *misclassification of certain groups*. UHCNIR is an indicator that specifically reflects problems related to health care access, and captures those who have lower resources and higher health care needs (e.g. individuals with a disability or a chronic health problem). So, a mismatch between deprivation scales and UHCNIR reflects the failure of the measure to capture those people in poverty with a health problem. This is inspected by examining the profiles of the missed group based on some economic and health indicators.

This misclassification is a significant validity problem only if it is systematic, due to a problem in the design of the measures. Deprivation scales might fail to identify those people in poverty with a disability or a chronic health problem due to their inability to account for need differentials in health care. If so, a relative income poverty measure also do not adjust for the differences in health care needs and then would also suffer from the same problem; however, an income inadequacy measure adjusts for need differentials (as individuals evaluate their overall resources against needs), and can

equally identify healthy and unhealthy groups. Therefore if the error occurs due to “need differentials”, only the income inadequacy measure would *not* suffer from it.

These hypotheses are formally tested in a regression setting, where measures are compared in their ability to estimate UHCNIR equally (with the same precision) across health groups. If a measure systematically misses “unhealthy poor”, it cannot predict the partial criterion variable equally across health groups, but predict worse for the unhealthy. Then, deprivation scales and relative income poverty measures are expected to estimate worse for the unhealthy groups and the income inadequacy measure is expected to estimate the criterion variable equally across health groups. The idea is to test the interaction effect of health status on the relationship between poverty measures and the criterion variable.

For an initial investigation of this, the odds of agreement between UHCNIR and poverty measures are compared across different health groups using Mantel-Haenszel method. Given all measures are binary, in a 2x2 cross tabulation, the cell frequencies “a” and “d” show the agreement, and “b” and “c” show the disagreement between the criterion variable and the poverty measure (Table 2).

**Table 2: Cross tabulations of poverty measure and criterion variable**

		Partial criterion variable (e.g. UHCNIR)		
		0	1	
Poverty measure	0	a	B	<b>Pr(agreement):</b> $(a/n) * (d/n)$ <b>Pr (disagreement):</b> $(b/n) * (c/n)$ <b>Odds ratio:</b> $(a*d) / (b*c)$
	1	c	D	

Notes: a, b, c, d are cell frequencies. n is the total sample size.

The odds ratios are calculated as the ratio of probability of agreement (a\*d) to the probability of disagreement (b\*c).<sup>14</sup> The null hypothesis is the homogeneity of odds ratios across health groups examined based on a chi-square test. We expect to reject the null for deprivation scales and relative income poverty measure but not for the income inadequacy measure.

To test the interaction effect of health status, variants of the following model are estimated for a deprivation scale, a relative income poverty measure and a subjective income inadequacy measure.

$$\text{logit (UHCNIR}_i) = \alpha + \beta_1 P_i + \beta_2 H_i + \beta_3 P_i * H_i + \beta_4 C + e_i$$

The dependent variable, UHCNIR is the criterion variable; P is a binary poverty measure (e.g. SMD index); H is a binary health indicator (1=bad health); P\*H is their interaction term and C represents the controls such as age.<sup>15</sup> To examine the significance of the interaction terms, first, the models are run with and without the interaction term for each poverty measure, and the deviance between the models are examined using likelihood-ratio test. The null hypothesis is equal likelihood between the models with and without interaction term. Then, we expect to reject the null hypothesis only for deprivation scales and relative income poverty measure but not for the income inadequacy measure.

Secondly, the significance and the direction of the estimated coefficients of the interaction terms are examined. In the proposed model, coefficient  $\beta$  represents the predictive power of a poverty measure. If the interaction term is significant, predictive

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<sup>14</sup> This is equivalent to running a logistic regression where UHCNIR is regressed on the poverty measures.

<sup>15</sup> UHCNIR is a binary variable so a logit transformation of UHCNIR is modeled. The coefficients are exponentiated so used in odds ratio forms. Interaction terms in odds term show multiplicative effects rather than marginal effects. Multiplicative interaction term controls for the baseline odds of healthy vs. unhealthy on UHCNIR (see Buis 2010).

power of the poverty measure for unhealthy individuals is  $\beta + \delta$ , while it is  $\beta$  for healthy individuals. If the interaction term is *significant* and *negative* (in odds ratio terms, a coefficient term lower than one), the poverty measure estimates worse for the unhealthy group. Then, a significant and negative interaction term in the models of the deprivation scale and the relative income poverty measure, and a non-significant interaction term in the model of the income inadequacy measure are expected.

#### **4. UHCNIR – a solid partial criterion variable for poverty?**

The indicator of unmet health care need has recently been proposed as a new indicator for assessing access to health care (Koolman, 2007; Allin and Masseria, 2009). Unmet need arises when an individual does not receive an available and effective treatment. Allin et al. (2010) define unmet need for health care as a multidimensional concept, distinguishing five different kinds or categories of unmet need: 1) *unperceived unmet need*, where an individual does not recognize her need for health care; 2) *subjective, chosen unmet need*, where an individual perceives himself as in health care need but does not demand the services available; 3) *subjective, not-chosen unmet need*, where an individual perceives herself as in some kind of health care need but does not receive services due to some access barriers beyond her control, 4) *subjective, clinician validated unmet need*, where an individual perceives himself a need for health care and accesses health care which validates his perception, but does not receive a treatment that a clinician would judge as appropriate, 5) *subjective unmet expectations*, where an individual perceives herself as in need for some kind of health care, receives care but in her view does not constitute a suitable treatment.

Given its relation to poverty, this paper focuses only on the third type of unmet need (using the follow-up question asking the respondents their reasons of unmet need). If an

individual does not receive a medical examination (e.g. a doctor's visit) or treatment (e.g. drugs, surgery) specifically because she cannot afford them, she experiences *subjective, not-chosen unmet need that occurs beyond her control* (Allin et al. 2010). There are various terms used in the literature such as cost-related medical non-adherence, foregone care, underutilization or underuse and cost barriers (Litwin and Sapire 2009). The term that is used in this study related to the survey question is "unmet health care need due to inadequate resources" (UHCNIR).

Such deprivation can be justified as a component of poverty given definitions used in relevant studies. Definitions of both consistent and consensual approaches can be categorized into two common main parts (Nolan and Whelan, 2007): "exclusion from society" and "inadequate resources". The latter is the *enforced criterion* –a deprivation of exclusion caused by a lack of economic resources and not by other reasons (e.g. preferences). For the former, approaches differ in their conception of "exclusion from society" (ordinary vs. minimum): Townsend (1979) focuses on a norm or an ordinary living pattern defined based on "objective" individual needs, while Mack and Lansley (1985) focuses on a minimum level based on "subjective" (and consensual) societal needs. *Therefore, a suitable partial criterion variable should be a deprivation which is caused by a lack of resources (enforced criterion), a part of accustomed living standard in the EU society (based on expert criterion) and be perceived by the majority of EU citizens as a socially perceived necessity (based on consensual criterion).*

In this context, having problems of access to health care (due to a lack of resources) can be considered as a component of the poverty experience for both approaches. In the EU, access to health care has long been one of the building blocks of the welfare states. Now almost at a universal level, citizens are covered by health care insurance which

enables their access to health care services and protects them against the financial impacts of unexpected health problems (OECD 2014). Also based on a special Eurobarometer survey, 77% of the people in the EU consider having “medical care when needed” as *absolutely* necessary for a minimally accepted living standard, the highest support among all other items (Dickes et al., 2010).<sup>16</sup>

However, despite the achievement of universal coverage for a comprehensive set of health care services in the EU, there are still reported problems of access ( Doorslaer et al., 2004; Allin and Masseria, 2012).<sup>17</sup> For example, in 2009, 4.2% of the EU 27 population reports having unmet health care needs, and approximately half of these are due to affordability problems.<sup>18</sup> The literature reports the key determinants for these access problems or having unmet health care need as the out-of-pocket payments and direct costs of care to patients (Devaux and De Looper, 2012; Fjær et al., 2017; Schokkaert et al., 2017).

Despite being perceived as a basic need and an ordinary part of living in an EU society, a small but significant group of people cannot access certain health care services because they cannot afford the direct costs of care. Therefore, having UHCNIR can be considered as living below a minimally accepted living standard or not being able to participate in ordinary living patterns in the EU. Moreover, the UHCNIR indicator

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<sup>16</sup> [http://www.poverty.ac.uk/system/files/poverty/eurobarometer\\_heatmap.html](http://www.poverty.ac.uk/system/files/poverty/eurobarometer_heatmap.html)

<sup>17</sup> The Health at Glance series of OECD periodically report the level of UHCNIR based on the data from EU-SILC. As shown by their latest study, the EU 27 average level of UHCNIR has been in decline between 2005 and 2009, from around 4% to around 2%, and then it has been stable in the period of 2009-2012 (OECD, 2014). However, this rate varies between low and high income groups. For the low income groups, the rate has been around 8% in 2005, decreased to 4% in 2010 and slightly increased to 4.5% in 2012, while the rate for the high income groups has been around 1% for the whole period between 2005 and 2012 (OECD 2014). The UHCNIR rates also considerably differ among EU (21) countries. The highest prevalence is around 7.5%, for example, in Romania, Latvia and Bulgaria. Yet in countries such as the UK, Czech Republic and Spain, the problem is less than 0.3%.

<sup>18</sup> Source: Eurostat <http://appsso.eurostat.ec.europa.eu/nui/show.do>

complies with the enforced deprivation criterion as it evaluates whether the deprivation is caused by a lack of economic resources. So theoretically, the UHCNIR indicator can be a good partial criterion variable for poverty for both consensual and consistent poverty approaches.

This can also be justified based on some empirical evidence showing a close relationship between UHCNIR and poverty (measured with the formal EU 2020 headline poverty measure). *Firstly*, there is a very high cross-country correlation for the EU countries between UHCNIR and poverty (0.86). *Secondly*, the risk profiles of UHCNIR and poverty are almost the same (see Table 3 and also Appendix). A specific sub-group is defined to be at risk if the ratio of the group among the people in UHCNIR (or poverty) is higher than the ratio of the group in the total population. For example, the ratio of unemployed among people in UHCNIR (14.45%) is significantly higher than the ratio of unemployed in total adult population (6.09%).

**Table 3: Risk groups for UHCNIR and poverty**

	<b>UHCNIR</b>	<b>EU2020 poverty indicator</b>
<b>Gender</b>	Female	Female
<b>Age group</b>	45-64, 65+	15-24, 45-64
<b>Household type</b>	Single person, Single parent, Extended family	Single person, Single parent, Extended family
<b>Marital status</b>	Widowed, Divorced	Never married, Widowed, Divorced
<b>Place of residence</b>	Thinly populated	Thinly populated
<b>Economic status</b>	Unemployed, Retired, Disabled, Unpaid domestic worker, Other inactive	Unemployed, Student, Disabled, Domestic unpaid worker, Other inactive
<b>Occupation</b>	Service workers, Skilled agr. and fishery worker, Craft trade workers, Elementary occupations	Service workers, Skilled agr. and fishery worker, Craft trade workers, Elementary occupations
<b>Health</b>	Fair, bad, very bad reported health, Disability, Chronic health problems	Fair, bad, very bad reported health, Disability, Chronic health problems

*Notes: The risk groups for UHCNIR (or poverty) are identified as the groups whose ratio within the people in UHCNIR (poverty) is higher than their ratio within the population. Data is presented at the Appendix.*

*Thirdly*, risk profiles reflect only bivariate associations, but even after conditioning the probability on other factors in a logit model, the close relationship between UHCNIR and poverty remains strong. After controlling for income, gender, age, marital status, and health problems (subjective health, disability and chronic health problems), the people in UHCNIR are three times more likely to be in poverty than others (see Appendix for results). These results provide a certain level of confidence in using UHCNIR as a criterion variable for poverty.

### 5. Results: examining empirical validity of deprivation scales

As described in Table 1, four main scales with their different variants are examined in the mismatch analysis. Two error statistics for Type II error,  $TIIE_1$  and  $TIIE_2$ , are calculated based on the cross tabulations of deprivation scales and UHCNIR. To illustrate the data and calculation of the statistics, raw results for Guio (2009)'s SMD index (4+) are presented at Table 4 below.

**Table 4: Mismatch analysis with a criterion variable of UHCNIR**

		UHCNIR		
		0	1	
SMD index	0	90.6%	<b>1.05%</b>	91.65%
	1	7.36%	0.99%	8.34
		97.97%	2.03%	100%

The results show a majority, around 90%, is neither in severe material deprivation nor in UHCNIR. Around 1% is identified by both measures; around 7% suffers only from SMD

and around 1% only from UHCNIR. This latter group of 1% indicates the  $TIE_1$  statistic: 1% of the population is in UHCNIR but not identified by the SMD index. The  $TIE_2$  statistic equals to  $1.05/2.03=0.52$ : the SMD index does not identify around 50% of the people in UHCNIR.

These error statistics are calculated for all considered deprivation scales as shown below in Table 5. For all measures, The  $TIE_1$  statistics are usually above 1% (except the MD variants in consensual approach): around 1% of the EU adult population is missed by the deprivation scales despite being in UHCNIR. In other words, this 1%, corresponding to 3.5 million adults, might be wrongly identified by the deprivation scales as “non-poor”. In some countries,  $TIE_1$  is around 3% e.g. in Greece, Italy and Romania, while it is close to zero in others e.g. the UK and Spain (see Appendix). Also,  $TIE_2$  statistics are around 0.50-0.75 (except the MD variants in consensual approach): more than half of those in UHCNIR are not identified as “poor” by the deprivation scales.<sup>19</sup>

The error statistics are substantively high given the assumption that the people who experience UHCNIR also experience poverty. But, firstly, is this assumption tenable? In other words, does this 1% who is in UHCNIR but missed by the scales really experience poverty? Secondly, for this error to be a significant validity problem, this 1% must reflect certain common characteristics and systematically be missed due to a structural problem in the design of deprivation scales. Hence, what is the source of error?

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<sup>19</sup> The relative validity of the deprivation scales can also be examined from this table. *Firstly*, the new versions of deprivation scales do not seem to improve the measurement performance compared to the old versions. This is likely because neither indices include an item related to access to health care. *Secondly*, indices with the lower thresholds perform better (MDs vs. SMDs). This result is also expected because higher thresholds constraint the number of people who falls below the cut-off. The higher the level of deprivation thresholds the lower the chance of identifying people with an UHCNIR problem. *Thirdly*, given the focus of consistent poverty measures on the intersection and more intense poverty experiences, the consistent poverty measures perform worse compared to the consensual measures.

**Table 5: Type II error statistics for deprivation scales**

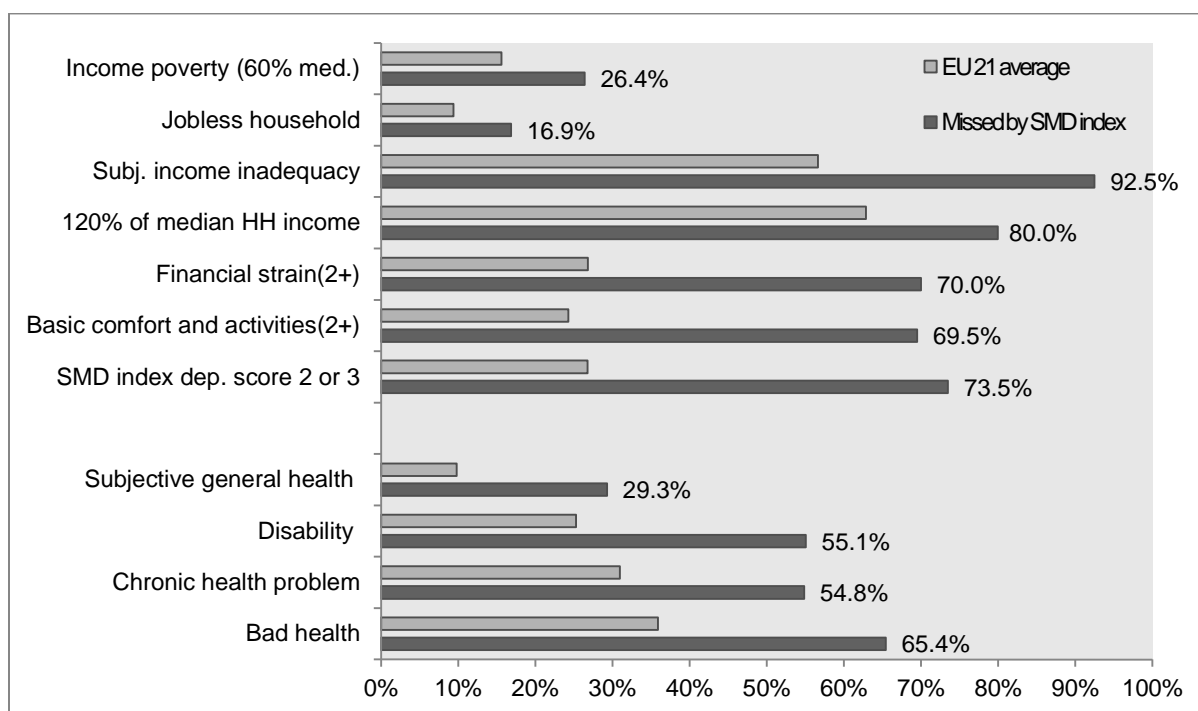
<b>CONSENSUAL APPROACH</b>			
Single deprivation scales where indicators identified with a consensual method			
<b>Deprivation scales</b>	<b>TII<sub>E1</sub></b>	<b>TII<sub>E2</sub></b>	<b>Headcount rate%</b>
<b>Guio 2009 – 9 item</b>			
3+ MD	0.006	0.31	17.4
4+ SMD	0.011	0.52	8.3
<b>Guio et al. 2016 – 13 item</b>			
5+ MD	0.006	0.29	20.2
7+ SMD	0.010	0.51	10.4
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <p><b>TII<sub>E1</sub></b>: Ratio of Type II error to total population</p> <p><b>TII<sub>E2</sub></b>: Ratio of Type II error to the # of people in UHCNIR</p> </div>			
<b>CONSISTENT POVERTY APPROACH</b>			
Deprivation scales combined with an income poverty measure (60% of national median equalized household disposable income)			
<b>Deprivation scales</b>	<b>TII<sub>E1</sub></b>	<b>TII<sub>E2</sub></b>	<b>Headcount rate%</b>
<b>Guio 2009 – 9 item</b>			
3+ MD	0.014	0.67	6.6
4+ SMD	0.015	0.75	3.8
<b>Guio et al. 2016 – 13 item</b>			
5+ MD	0.014	0.68	7.2
7+ SMD	0.015	0.76	4.3
<b>Nolan and Whelan 2011 – 7 item</b>			
2+ MD	0.013	0.63	10.2
3+ SMD	0.014	0.67	6.8
<b>Whelan and Maitre 2012 – 9 item</b>			
2+ MD	0.013	0.63	9.7
3+ SMD	0.013	0.66	7.3

5.1. *Relaxing the assumption of partial criterion variable*

To test the partial criterion variable assumption, hence further investigating the poverty status of this 1%, other poverty indicators can be observed. Table 6 below shows the incidence of relative income poverty, work intensity, subjective income inadequacy (form II), having household income below 120% of median for the missed 1%. A “financial

strain” index<sup>20</sup> proposed as a validity index by Maitre et al. (2013), and a “basic comfort and activities” index<sup>21</sup> are also examined. This analysis held only for the SMD index but the results are similar for other scales.

**Table 6: Does this 1% experience poverty?**



Notes: The table gives rates of some poverty-related indicators for the 1% who are missed by the SMD index of Guio (2009) despite being in UHCNIR. The EU average numbers are the rates for the adult EU population. The financial strain rate indicates the ratio of people who are deprived of two or more items from the 5-item list of financial strain index (see Footnote 12). The basic comfort and activities rate indicates the ratio of people who are deprived of two or more items from the 5-item list of basic comfort, leisure and social activities index (see Footnote 13).

As shown in Table 6, among these 1% missed by deprivation scales despite being in UHCNIR, around 26% is in income poverty and 17% lives in jobless households.

<sup>20</sup> The items are i) serious difficulty meeting ends meet (form I), ii) feeling heavy burden of housing cost, iii) feeling heavy burden of debt, iv) having arrears for rent, mortgage or utility bills, v) not being able to face unexpected expenses. The Cronbach alpha for the scale is 0.69. The index score is sum of deprived items (all binary).

<sup>21</sup> The items are ability to afford to i) spare money for oneself, ii) leisure activities, iii) drink/meal out with friends monthly, iv) replace worn-out furniture, v) yearly go on a holiday. The Cronbach alpha for the scale is 0.77. The index score is sum of deprived items (all binary).

Although these rates are significantly higher than the EU average (15.6% for income poverty and 9.4% for jobless households), majority of this 1% is still not in income poverty and does not have low work intensity. On the other hand, almost all of this 1% reports having inadequate income (93%); 70% reports two or more deprived items from the 5-item financial strain index (compared to an EU average of 26%); 70% reports two or more deprived items from the 5-item index on “basic comfort and social activities” (compared to an EU average of 24%); and, only around 10% does not report any deprivation out of these three deprivation indices.

Therefore, despite not being identified by the SMD index, *the majority* of this 1% not only experience UHCNIR but also suffer from multiple other deprivations and reports some difficulties making ends meet. Also, when the risk profiles of this 1% are compared to the poverty risk profiles explored before, they are exactly the same as in Table 3. Therefore in all relevant indicators, this group shows very similar characteristics to the people in poverty.

## 5.2. Sources of error

But despite not being jobless or in income poverty, why do these people significantly report having difficulties making ends meet? One reason for this might be extra costs related to having *higher health care needs*. The UHCNIR indicator reflects a condition of having inadequate resources relative to the needs for health care. The people identified by the UHCNIR typically have lower resources and higher health care needs (Koolman 2007; Allin and Masseur 2012). This is also valid for this 1% – around 80% of them fall below 120% of the median household income; also, around 29% reports bad subjective health, 55% has a disability or a chronic health problem, and around 65% suffers from either of these three. These are significantly high numbers compared to the EU average.

An individual with a disability or chronic health problem might need periodical medical checks or need to regularly take pharmaceuticals. These all means higher costs, for example, given the amount of co-payments or transportation expenses. Indeed, as referred before, the evidence suggests that the main factor explaining UHCNIR is the amount of out-of-pocket payments. Therefore, economic resources of this 1% might be adequate to put them above the relative income poverty thresholds despite still not being enough to meet their health care needs. Indeed, majority of this 1% locates just above the relative income poverty threshold - 60% have incomes lower than the 4<sup>th</sup> decile and 80% is below the 6<sup>th</sup> decile or below 120% of median income. *Therefore, the issue of this 1% is not low income but inadequate income.*

As argued before, deprivation scales also cannot fully account for the poverty experiences of the people with a health problem because these scales do not include a relevant deprivation item that can adjust for these need and cost differentials. Despite suffering from lower resources and multiple deprivation, this 1% might be missed by deprivation scales as their distinct need patterns translate into a different threshold in a scale where health care needs are not included. Indeed 74% of the people not identified by the SMD index are still deprived of two or three items from the SMD index, so locates just below the threshold of four, but still not identified as in poverty by the index.

### 5.3. *Testing the arguments*

The results have shown that deprivation scales miss a sizable group of “unhealthy poor”. If so, deprivation scales cannot predict the partial criterion variable equally across health groups. Also, the source of such error is hypothesized to be the inability of such measures to adjust for need differentials in health care. Then, a relative income poverty measure also do not adjust for need differentials hence would suffer from the same

problem, while an income inadequacy measure would be free from such error. Therefore, if need differentials problem causes missing specifically the unhealthy poor, deprivation scales and income poverty measure would be expected to estimate the criterion variable worse for the “unhealthy” while income inadequacy measure would be expected to estimate the partial criterion variable equally across health groups.

To test these hypotheses, firstly the odds of agreement between poverty measures and UHCNIR are compared across different health groups using Mantel-Haenszel method. For this analysis, three binary health indicators are used: reporting bad subjective health, reporting a chronic health problem, and reporting a disability problem. The results are presented at Table 7. (The analysis is only presented for the SMD index, but the results are similar for other scales.)

For all measures, the odds of agreement between the poverty measures and UHCNIR are higher for healthy compared to the unhealthy groups. For example, SMD index and UHCNIR are about 10 times more likely to agree than disagree for the group with good subjective health, while this number is 6.3 for the group with bad subjective health. However, the differences between the odds ratios of healthy and unhealthy groups are statistically significant only for the SMD index and the relative income poverty measure, but not for the income inadequacy measure.

These results show that associations of the SMD index and the relative income poverty to the criterion variable depend on the health status. The SMD index and the relative income poverty measure estimate the criterion variable better for healthy, while the income inadequacy measure predicts equally across health groups.

**Table 7: UHCNIR and poverty measures – odds of agreement across different health groups**

	<b>Odds ratio</b>	<b>95% confidence interval</b>	<b>Test of homogeneity</b>
<b><i>SMD index</i></b>			
Subj. health = 0	9.6	9.1-10.2	Chi2(1)=81.13
Subj. health = 1	6.3	5.8-6.8	Pr>chi2= <b>0.0000</b>
Chronic health pr. = 0	10.2	9.5-10.9	Chi2(1)=13.52
Chronic health pr. = 1	8.6	8.1-9.1	Pr>chi2= <b>0.0002</b>
Disability = 0	10.2	9.6-10.9	Chi2(1)=30.57
Disability = 1	7.9	7.5-8.4	Pr>chi2= <b>0.0000</b>
<b><i>Relative income poverty</i></b>			
Subj. health = 0	3.7	3.5-3.9	Chi2(1)=49.75
Subj. health = 1	2.6	2.4-2.8	Pr>chi2= <b>0.000</b>
Chronic health pr. = 0	4.3	3.9-4.6	Chi2(1)=49.75
Chronic health pr. = 1	2.9	2.8-3.2	Pr>chi2= <b>0.000</b>
Disability = 0	3.8	3.6-4.1	Chi2(1)=32.07
Disability = 1	3	2.8-3.1	Pr>chi2= <b>0.000</b>
<b><i>Income inadequacy</i></b>			
Subj. health = 0	17.4	14.9-20.4	Chi2(1)=2.48
Subj. health = 1	13.6	10.3-18.2	Pr>chi2= <b>0.1155</b>
Chronic health pr. = 0	21.3	17.3-26.5	Chi2(1)=2.99
Chronic health pr. = 1	16.8	14.1-19.9	Pr>chi2= <b>0.084</b>
Disability = 0	19.6	16.1-24	Chi2(1)=2.52
Disability = 1	15.8	13.1-19.1	Pr>chi2= <b>0.1123</b>

Secondly, to test the significance of interaction terms, six logistic regressions for each three poverty measure are run. For each three health indicators, the models are run with and without interaction terms for each of the three poverty measures (model is presented in the methods section, pg. 14). The aim is to examine i) whether adding interaction terms improves the models based on log likelihoods and deviance statistics; and ii) the significance of the interaction terms. The results are shown in Table 8 below.

**Table 8: UHCNIR and poverty measures - testing interaction effect of health status**

	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>	<b>Model 5</b>	<b>Model 6</b>
Guio'09 (4+) - <i>SMD index</i>	9.75***	11.48***	11.28***	11.82***	10.43***	12.07***
Subjective health	3.41***	4.38***				
SMD * subj. health		.605***				
Chronic health prob.			2.57***	2.67***		
SMD * chronic health pr.				.917		
Disability					3.56***	4.00***
SMD * Disability						.768***
	-33663.9	-33613.7	-33697.5	-33686.6	-33384.5	33362.5
		100.3		21.9		44.1
		0.0000		0.0000		0.0000
	<b>Model 7</b>	<b>Model 8</b>	<b>Model 9</b>	<b>Model 10</b>	<b>Model 11</b>	<b>Model 12</b>
Income poverty ( <b>IP</b> )	3.16***	3.49***	3.46***	4.17***	3.21***	3.69***
Subjective health	4.69***	5.274***				
IP * subj. health		0.76***				
Chronic health prob.			2.78***	3.15***		
IP * chronic health pr.				0.72***		
Disability					4.03***	4.40***
IP * Disability						0.79***
	-36204.1	-36173.5	-36555.4	-36519.9	-36167.7	36147.5
		61.2		70.9		40.4
		0.0000		0.0000		0.0000
	<b>Model 13</b>	<b>Model 14</b>	<b>Model 15</b>	<b>Model 16</b>	<b>Model 17</b>	<b>Model 18</b>
Income inadequacy ( <b>II</b> )	15.16***	15.57***	17.42***	20.49***	16.06***	16.92***
Subjective health	3.81***	4.37***				
II * subj. health		0.87				
Chronic health prob.			2.71***	3.56***		
II * chronic health pr.				0.75		
Disability					3.74***	4.13***
II * Disability						0.90
Log likelihood	-35192.8	-35191.1	-35374.8	-35372.8	35049.7	-35047.9
Lrtest chi2		3.4		4.1		3.6
Lrtest p		0.0671		0.0439		0.0597
N	350,408	350,408	350,408	350,408	350,408	350,408

*Notes: The dependent variable for all models is UHCNIR. The results for the coefficients are presented in odds ratio terms. The model is presented for Guio (2009) but other deprivation scales give similar results and available upon request. The models include age as a control.*

The deviance between the models with and without interaction terms is significant for the models of SMD index and relative income poverty, while it is not significant for the income inadequacy. This means adding the interaction term to the model makes a significant difference only for the SMD index and the relative income poverty measure.

In addition, the interaction terms are generally significant for the models of SMD index and relative income poverty measure, but not for the models of income inadequacy.<sup>22</sup>

This shows that the predictive power of SMD index and relative income poverty depends on the health status of individuals while the income inadequacy measure predicts equally across health groups. Moreover, as the coefficients of the interaction terms are lower than one, the SMD index and the relative income poverty measure predicts the criterion variable worse for the unhealthy groups. For example, the predictive power of SMD index is 40% lower for those reporting bad health compared to those not reporting, and around 23% lower for those reporting a disability problem compared to those not reporting; the predictive power of income is 28% lower for those reporting a chronic health problem compared to those not reporting. On the other hand, non-significant interaction terms in the models for income inadequacy show the ability of this measure to estimate equally for different health groups, and not missing specifically the unhealthy groups.

These evidences reinforce the arguments that deprivation scales tend to specifically miss the people in poverty with a health problem, and this error is not random and due to random and due to not accounting for the health care need differentials; or due to missing dimensions within deprivation scales.

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<sup>22</sup> Only the interaction term with chronic health problem is not significant for SMD index; yet, it still is substantively lower than one (around 0.9).

## 6. Conclusion

The study investigated the empirical validity of deprivation scales, from the health care aspect of poverty, and the sources of such error. Given that existing correlational evidence based on construct validation does not provide an adequate basis for examining absolute validity, an alternative approach based on a partial criterion variable is employed. In this approach, UHCNIR (unmet health care need due to inadequate resources) is used as a criterion for identifying some people in poverty with a significant health problem. Theoretically, this type of deprivation is a component of poverty given the definitions used in the relevant studies. Empirically, the indicator identifies mostly people with lower resources, and a significant health problem (e.g. disability), and highly correlates with and produces similar risk profiles to the formal poverty measures. A mismatch analysis between deprivation scales and UHCNIR then identifies those individuals who can be defined as poor but missed by deprivation scales – Type II error.

The results of the mismatch analysis show that the existing deprivation scales miss a sizable group of adults – 3.5 million – who reports having unmet health care needs due to inadequate resources (UHCNIR). Despite not being identified by the scales, three out of four of this 1% experiences multiple other deprivations in basic comfort and social activities, and in financial strain; most of them have limited resources to meet their needs (80% have income lower than 120% of median); and, almost all (around 90%) report having some difficulties making ends meet.

This Type II error is a significant empirical validity problem because it results in systematic misclassification of the unhealthy poor and is attributable to a limitation in the design of deprivation scales – namely missing dimensions problem. Around three out of five missed by the scales has either a disability or a chronic health problem. Deprivation

scales specifically miss these “unhealthy poor” because varying health care needs and costs are not taken into account in the design of these measures. For the same reason, the relative income poverty measure also misses the same group, but the subjective measure of income inadequacy do not suffer from the same problem as it by design adjusts for need differentials.

Lowering thresholds appears to be one solution to mitigate the identified error. For all deprivation scales, lower thresholds (MDs) performed significantly better than higher thresholds (SMDs). Decreasing the threshold of Guio (2009) from 4+ to 2+ reduces the error by 2.5 million people, down to 0.3% of the adult population and 13.6% of the people in UHCNIR. This finding shows that validity is partially related to the level at which the thresholds are set. However, lowering the threshold might create other problems, possibly Type I errors, making this, at best, an *ad hoc* without much certainty about its effect on the overall error.

The contribution of this paper is threefold. The first relates to the methodology of validity evaluation. An appropriate selection and use of a partial criterion variable can help to identify the misclassification of certain groups and hence allows us to provide evidence on the empirical validity of poverty measures. Secondly, using this method, the paper provides empirical evidence on Type II errors in relation to a specific aspect of poverty – access to health care due to affordability problems. Thirdly, the paper explores the sources of error, which are embedded in the discussion on “conversion factors” and multidimensionality of poverty measurement.

Despite pointing to significant validity problems in the measurement of poverty arising from unmeasured health-related costs, the analysis does not provide a complete evaluation of empirical validity. There are two limitations of the proposed method based

on a partial criterion variable. Firstly, such an analysis perforce focuses on a specific aspect of poverty. Hence, to gain a more comprehensive understanding of empirical validity, further research employing other partial criterion variables for different aspects of poverty is necessary. Secondly, and relatedly, only Type II errors are evaluated. As a result, the analysis provides only partial evidence on under or over-estimation of poverty numbers. In theory, the same method can be adapted to estimate the extent of Type I errors. These two issues, however, can best be the matters for future research.

An important implication for poverty measurement arising from the analysis concerns the design of measures. Need differentials are not limited to health care. People also differ in their needs for education, transportation, child care or various other public or private goods and services that alter living conditions. Then, to account for the different experiences of poverty, unidimensional deprivation scales based on *some key* indicators might be insufficient. Employing more comprehensive equivalence scales or using measures including indicators from *each relevant dimension* might be the only way to adjust for varying need patterns. Yet, this option requires explicitly identifying the dimensions of poverty prior to their measurement. Only then, can aspects where adjustments for need differentials are necessary be comprehensively identified and relevant indicators for each dimension be devised. In other words, an elaborate theoretical definition that specifies the dimensional structure of poverty is a necessary condition for reaching empirically valid measures. In the interim, data limitations, however, are still the main concern.

## 7. Appendix

**Table A1: Description of variables used in the analysis**

<b>Variable</b>	<b>Survey Question / Description</b>	<b>Scale</b>	<b>Recode</b>
<i>UHCNIR – unmet health care need due to inadequate resources</i>	<p>a. “Was there any time during the last twelve months when, in your opinion, you personally needed a medical examination or treatment for a health problem but you did not receive it?”</p> <p>b. (for those positively answer question a) what are the reasons for this unmet health care need?</p> <p><i>derived using questions a and b – answering yes to the question a and stating “could not afford to” for the question b</i></p>	<p>a. 1: yes at least one case / 0: no</p> <p>b. multiple categories from 1 to 8<sup>23</sup></p> <p>Binary – 0 / 1</p>	
<i>Subjective health</i>	“How is your general health?”	Interval 1 to 5 1: Very good 5: Very bad	Binary – 1 if SH>3 0 otherwise
<i>Disability</i>	“For at least the past 6 months, to what extent have you been limited because of a health problem in activities people usually do? “	Binary – 0 / 1	
<i>Chronic health problem</i>	“Do you have any longstanding (6 months or more) illness or health problem?”	Binary – 0 / 1	
<i>Bad health</i>	<i>derived</i> – reporting bad subjective health or disability or chronic health problem	Binary – 0 / 1	
<i>SMD index (EU’s formal pov. measure)</i>	<i>derived</i> – 9-item index of Guio (2009)	Binary – 1 if SMD> 3; 0 otherwise	Interval – 0 to 9

<sup>23</sup> 1: could not afford to (too expensive) / 2: waiting list / 3: could not take time because of work, care for children etc. / 4: Too far to travel – no means of transportation / 5: Fear of doctor – hospitals – examination - treatment / 6: Wanted to wait and see if problem got better on its own / 7: Didn’t know any good doctor or specialist / 8: Other

<i>Relative income poverty (EU's formal pov. measure)</i>	<i>derived</i> – Having equalized household income below 60% of median household equalized income	Binary – 0 / 1	
<i>Work intensity / joblessness (EU's formal pov. measure)</i>	<i>derived</i> – Eurostat definition	Binary – 0 / 1	
<i>EU 2020 poverty headline indicator (at-risk-of-poverty and social exclusion)</i>	<i>derived</i> – Being identified as “poor” by SMD index or Income poverty or joblessness measures	Binary – 0 / 1	
<i>(Subj.) income inadequacy</i>	“Thinking of your household’s total income, is your household able to make ends meet, namely, to pay for its usual necessary expenses?”	Interval 1 to 6 1: With great difficulty 3: With some difficulty 6: Very easily	<i>Binary form I:</i> 1 if SII<3 0 otherwise <i>Binary form II:</i> 1 if SII<4 0 otherwise

**Table A2: Risk profiles for UHCNIR and poverty**

		<b>Total population</b>	<b>UHCNIR</b>	<b>EU2020</b>
Gender	<b>Female</b>	52.32	<b>61.08</b>	<b>55.7</b>
Age group	15-24	12.75	7.07	<b>15.49</b>
	25-44	34.36	29.28	31.42
	<b>45-64</b>	31.98	<b>39.36</b>	<b>32.84</b>
	65+	20.91	<b>24.29</b>	20.25
HH type	<b>Single person</b>	15.4	<b>22.08</b>	<b>22.22</b>
	2+ adults 0 child	43.4	38.54	35.58
	<b>Single parent</b>	2.93	<b>4.42</b>	<b>5.88</b>
	2 adults 1+child	26.84	18.71	23.37
	<b>Extended family</b>	11.2	<b>14.79</b>	<b>12.63</b>
Marital status	Never married	29.58	22.16	<b>34</b>
	Married	54.56	49.43	44.42
	<b>Divorced/Separated</b>	<b>15.87</b>	<b>28.41</b>	<b>21.58</b>
Degree of urbanization	Densely	49.38	44.18	45.4
	Intermediate	26.24	21.63	22.64
	<b>Thinly</b>	24.38	<b>34.19</b>	<b>31.97</b>
	Full-time	42.66	24.77	22.5
	Part-time	7.93	7.04	6.8
Economic status	<b>Unemployed</b>	6.09	<b>14.45</b>	<b>14</b>
	Student/trainee	7.38	2.56	9.65
	Retired	23.59	<b>28.4</b>	23.55
	<b>Disabled</b>	2.8	<b>7.09</b>	<b>6.94</b>
	<b>Domestic unpaid worker</b>	7.24	<b>10.83</b>	<b>12.15</b>
	<b>Other inactive</b>	2.31	<b>4.87</b>	<b>4.4</b>
Occupation	Managers/senior officials	6.76	2.74	4.28
	Professionals	12.2	4.16	4.8
	Technicians/ass. professionals	15.59	8.35	9.17
	Clerks	11.68	7.91	8.6
	<b>Service workers</b>	12.92	<b>14.44</b>	<b>14.8</b>
	<b>Skilled agr. and fishery</b>	5.39	<b>12.92</b>	<b>10.95</b>
	<b>Craft trade workers</b>	14.19	<b>17.93</b>	<b>17.14</b>
	<b>Plant/machine operators</b>	8.48	<b>9.37</b>	<b>9.42</b>
	<b>Elementary occupations</b>	12.23	<b>21.91</b>	<b>20.56</b>
	Army	0.57	0.28	0.29
Subj. health	<b>Bad</b>	9.8	<b>34.68</b>	<b>16.51</b>
Chronic health problem	<b>Yes</b>	30.93	<b>56.11</b>	<b>36.61</b>
Disability	<b>Yes</b>	25.28	<b>56.73</b>	<b>33.53</b>

**Table A3: Is UHCNIR a significant predictor of poverty?**

	Poverty (eu2020) or/se
<b>UHCNIR</b>	<b>3.055<sup>***</sup></b> <b>(0.09)</b>
Log equiv. HH income	0.222 <sup>***</sup> (0.00)
Female	1.155 <sup>***</sup> (0.01)
Age	
15-24	0.842 <sup>***</sup> (0.01)
25-44	1.000 (.)
45-64	1.218 <sup>***</sup> (0.02)
65-80	0.813 <sup>***</sup> (0.01)
80+	0.893 <sup>***</sup> (0.02)
Marital status	
Never married	1.000 (.)
Married	0.495 <sup>***</sup> (0.01)
Separated	1.350 <sup>***</sup> (0.05)
Widowed	0.611 <sup>***</sup> (0.01)
Divorced	0.944 <sup>**</sup> (0.02)
Subjective health	1.194 <sup>***</sup> (0.02)
Disability	1.460 <sup>***</sup> (0.02)
Chronic Health Problem	1.141 <sup>***</sup> (0.02)
N	349438

Exponentiated coefficients; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

**Table A4: Error statistics for the SMD index for all countries**

	<b>TII<sub>E1</sub></b>	<b>TII<sub>E2</sub></b>
AT	0.16	51.4
BE	0.29	50.1
BG	1.48	19.8
CY	2.08	64.5
CZ	0.12	39.9
DE	0.72	56.8
EE	0.48	59.5
EL	2.64	65.3
ES	0.12	66.4
FR	0.86	55.2
HU	0.57	39.2
IE	0.9	79.2
IT	2.37	61.6
LT	0.42	56.5
LU	0.28	71.5
LV	3.55	45.5
MT	0.76	71.1
PL	1.38	50.4
PT	1.88	69.4
RO	2.95	37.8
SK	0.2	67.7
UK	0.05	80

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**Paper 2:**

**Missing dimensions?**

**Calibrating deprivation scales of poverty using perceived financial adequacy**

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## **Abstract**

This article probes for missing dimensions within the deprivation scales of poverty. Using British Household Panel Survey (BHPS) data from 1999-2008 and a self-assessed measure of financial adequacy as a proxy for poverty status, the analysis shows that, independent of the deprivation status, having needs in health care, child care, social care and education increases the probability of poverty. The effects of having needs in these dimensions which are typically missing from poverty measurement are mainly explained by their financial impact on households through greater expenses and reduced potential earnings, and not by state dependence, anticipation and psychological negativity bias that might arise from using a self-assessed measure of financial adequacy. The results are robust for different thresholds and specifications of the deprivation index. Also, combining deprivation and income measures (e.g. union or intersection approach) does not change the results. These findings demonstrate the need for more comprehensive measures. Unless relevant indicators of missing dimensions such as cost-related unmet needs in health care, child care, social care and education are included in the analysis, deprivation scales might fail to identify some people experiencing poverty.

**Keywords:** missing dimensions of poverty; material deprivation indices; equivalence scales; unmet need for health care; out-of-pocket payments; cost of childcare; needs for care; needs for education; cost-related unmet needs; multidimensional measurement of poverty

## 1. Introduction

Can deprivation scales with a limited set of items accurately identify people in poverty? From their debut with Townsend (1979) to this day (*inter alia* Guio et al., 2016), material deprivation indices have typically been used in a summary format whereby a scale based on a few selected indicators is taken to represent a much broader concept of poverty. For example, deprivation indices usually include items related to the experience of deprivation of food, fuel, clothes and shoes, and certain comfort goods and social activities (see e.g. Guio, 2009; Nolan & Whelan, 2011; Whelan & Maître, 2012; Guio et al., 2016). But they exclude needs related to health care, child care, social care and education. Still missing dimensions are not necessarily a problem for measurement (Nolan and Whelan, 2007). Even if a measure does not include items related to all dimensions of poverty, a few deprivation indicators representing “key aspects of living” can be adequate to identify people in poverty (Marlier et al., 2007: 177). The main assumption of deprivation scales is that those who have deprivations related to the measured dimensions will also have deprivations in unmeasured dimensions, hence will be captured by the measure.

If that assumption does not hold, three main functions of poverty measurement are not fulfilled. First, as a direct consequence, the identification of poverty would be fallible, as some people experiencing poverty related to the missing dimensions might be missed by the summary index. Secondly, missing dimensions can affect our ability to consistently monitor changes in poverty rates if poverty cases related to missing dimensions systematically vary over time. For example, Reeves et al. (2015) show how the trend in unmet need for necessary health care in the EU was downward for many years prior to the crisis in 2008 but was reversed after that, mainly affecting the groups with the lowest

incomes and mostly due to higher out-of-pocket payments (see also Schokkaert et al., 2017). Thirdly, missing dimensions can affect our ability to assess the impact of relevant social policies. For example, in a recent study, Nelson (2012) finds that total spending on public services is not associated with the risk of material deprivation when controlled for spending on social assistance. Nelson then speculates on the possibility of an indirect effect of public services - yet the direct effect might be missing due to the specification of the material deprivation index.

Despite its importance for the analysis of poverty and European social policy, there have not yet been any empirical attempts to study the consequences of missing dimensions for measurement (see Beduk, 2016 for an exception). Previous research on missing dimensions has mainly been conceptual, within the international development context and often related to the capability framework (Alkire, 2007; Jo, 2013).<sup>24</sup> In this article, I aim to provide empirical evidence on missing dimensions that are crucial for the measurement of poverty within the European context based on the relative deprivation framework. I mainly focus on dimensions such as health, child and social care and education, which are generally considered to be essential in leading a decent life in today's EU, and also constitute a significant part of contemporary welfare systems. I examine whether having needs in these dimensions which are typically not included in deprivation scales affect poverty status even after controlling for the deprivation measure. The main hypothesis is that having needs in these dimensions affect poverty status through their extra financial costs on the household – through greater expenses or reduced potential earnings.

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<sup>24</sup> These studies emphasize the absence of dimensions such as employment, empowerment, physical safety, and shame and the lack of sound, internationally comparable data and indicators for these dimensions.

To test this hypothesis and probe for missing dimensions, following the long tradition in relevant literature, I use a self-assessed measure of financial adequacy as a proxy for poverty. This measure reflects the balance of individuals' economic resources against their overall material and social needs, and hence can be considered as a good proxy for poverty defined in Townsendian terms. However, various endogeneity problems arise out of using a self-assessed measure. Hence, by using a dynamic correlated random-effect model, I control for time constant unobserved factors such as those relating to scale heterogeneity and personality traits. Such model also allows me to account for state dependence and anticipation bias given its dynamic nature, and psychological negativity bias as I can examine the heterogeneity of effects across people with different personality traits such as neuroticism and conscientiousness.

The analysis is applied for the UK using British Household Panel Survey (BHPS) data from 1999-2008. The UK is distinctive in having the most liberal market-oriented welfare system in the EU and thus provides a suitable test for examining the impact of needs in non-market goods on poverty. Implications for other EU countries are discussed in the conclusion. Lastly, two further issues are considered. First, as deprivation scales are used in different forms, I examined whether changing the applied thresholds or the design of the measure affects the conclusions of the analysis. Secondly, as deprivation scales are generally used alongside income poverty measures, I also examine whether combining deprivation and income poverty measures affect the conclusions. I test multiple designs such as i) the union approach adopted by the EU 2020 poverty target measure, and ii) the intersection approach (or consistent poverty approach) adopted by Ireland and in UK's child poverty measure. The results for these analyses are summarized in the sensitivity analysis section and presented in Supplementary Material.

## **2. Calibrating poverty measures and missing dimensions problem**

Measures of financial situation based on respondent's self-assessment are commonly used in the poverty scholarship, mainly for two purposes. Some studies are of the view that subjective measures provide extra useful information, for example, on the feelings of poverty hence should be used as actual measures of poverty (e.g. Fusco, 2016); while others have argued that such subjective measures are useful only for calibrating existing poverty measures (e.g. Ravallion, 2012). In both perspectives, one main reason behind the use of such subjective measures is accounting for missing dimensions.

For example, many studies have used self-assessed measures of economic well-being to calibrate income poverty thresholds. Using a subjective income-evaluation question, Hagenaars & Praag (1985) identified the elasticity of the poverty line to the median household income as 0.51 which has since been widely used as a relative poverty line (cf. Pradhan & Ravallion, 2000). Using a subjective minimum income question, Kapteyn et al. (1985) calculated the equivalence scales for adjusting incomes across households with different family sizes. Using self-assessment of financial situation, Zaidi and Burchardt (2005) identified the extra costs related to disability; Ravallion & Lokshin (2006) tested the utility consistency of poverty lines across households with different needs.

These studies show the need for more general equalization scales, the importance of accounting for the differences in material and social needs across households, and point out the missing dimensions when evaluating poverty using income. A recent official attempt to mitigate some of these problems is the Supplemental Poverty Measure (SPM) developed by the US Census Bureau which takes into account expenses related to

health care, mortgage, child care and work (e.g. transportation) (Short, 2011). Also, a recent project in Europe delves into similar issues using reference budgets (Goedeme et al., 2017).

Although presented as a response to these problems of income poverty measures, the same problems are still relevant also for deprivation scales. In the deprivation space, the method for equivalization or accounting for varying needs across households is to include relevant deprivation items into the existing index. For example, differences in needs for health care can be accounted for by including a relevant item regarding unmet health care need. When relevant items are not included, as is the case for example for the EU's material deprivation measure, the index systematically misses those people in poverty with higher health care needs such as those with a disability or a chronic health problem (Beduk, 2016). This issue is called here as the *missing dimensions* problem.

Many deprivation scales have recently been proposed to assess poverty for the EU. For example, a 9-item index proposed by Guio (2009) is part of a formal measure of poverty and social exclusion to monitor the EU 2020 poverty target. This has recently been updated to a 13-item index by Guio et al. (2016). Similar indices are also proposed by Nolan and Whelan (2010) and Whelan and Maitre (2012). All these measures are designed as summary indices covering some but not all aspects of poverty. This is partly due to data limitations. Given a history of ad hoc development of data on deprivation (in ECHP, EU-SILC or BHPS), the available items do not represent a coherent conceptual framework; nor do they adequately cover the whole concept of poverty as relative deprivation (Nolan and Whelan, 2011; Berthoud and Bryan, 2011; Maitre et al. 2013).<sup>25</sup>

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<sup>25</sup> The use of poverty as social exclusion aims to reflect the conceptual understanding of poverty proposed by Townsend (1979) hence implies.

Therefore, inevitably there are missing dimensions within the material deprivation indices. Typically, these indices do not account for needs in health care, child care, social care and education.

Moreover, as shown by Beduk (2016), not accounting for these dimensions might affect the ability of deprivation scales to identify people in poverty. This is mainly because needs in these dimensions either translate into extra spending or hamper possible earning potential of households which can force them into poverty.<sup>26</sup> Evidence about this can be shown for each of these four dimensions:

**Health care.** Despite the universal free-at-the-point-of-use health care services in the UK, 15% of total health spending was household out-of-pocket payments in 2012, which increased by 50% in the period between 1997 and 2008 (ONS, 2014). The out-of-pocket payments include spending on pharmaceuticals, medical equipment and contributions to long-term care. These types of medical expenses are particularly important for people with chronic health conditions as the necessity for long-term follow-up may incur cumulative out-of-pocket spending. Also, people with chronic health problems have lower employment rates, are more likely to exit employment earlier, have fewer working hours and lower earnings both in the UK and across the EU (OECD, 2016).

**Child care.** In a recent analysis, Flynn (2017) shows that, across EU countries, increases in out-of-pocket payments for childcare result in decreases in the number of working hours for mothers. In the UK, the incentives for work for an average worker with a young child are low due to the very high cost of child care net of benefits and tax concessions (OECD, 2011). A recent study shows that 73% of women aged 15-64 with

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<sup>26</sup> Another option is that people forgo their needs, in other words, experience unmet needs, which already make them financially insufficient.

children up to mandatory school age gave the affordability of child care as the main reason for not working or working part time (Mills et al., 2014).

**Social care.** A recent systematic review by Keaton et al. (2014) identified the main economic costs of long-term care for adult caregivers as i) reduced or foregone income due to restricted working hours and absences, and ii) out-of-pocket payments related to spending on housing (e.g. maintenance, modification and utilities), care services (e.g. professional and acute care services, child care or housekeeping), supplies (e.g. food, clothes, household goods, medications and equipment) and transport. In the UK, 58% of caregivers report incurring substantial out-of-pocket expenses due to long-term caring, while around one third report having spent previous savings and acquired debt to cover the costs of care (Carers UK, 2007). A recent paper estimated the cost of older people with a relatively severe disability as 100£ per week (Morciano et al., 2015). Old-age care also affects labor supply. For example, Løken et al. (2016), based on a quasi-experimental analysis for Norway, find that an increase in formal long-term care has a significant positive impact both on the labor supply and earnings of the adult daughter.

**Education.** Although the compulsory primary and secondary education (between age 5 and 16) is free in the UK, extra costs related to schooling such as transport, school lunches, uniform and textbooks, school trips and extracurricular activities were estimated yearly to be around 736 £ per child in 2003 (563 £ for primary school pupil and 968 £ for secondary school pupil) (Brunwin et al., 2004). In the UK compared to other EU countries, tuition fees for higher education are substantively higher. In 2008, the cost for one year of tertiary education for an individual was estimated to be around 2000 USD on average across the OECD, while it was around 5000 USD in the UK (OECD, 2012). In addition to the considerable financial impact of tuition fees on household budgets,

Dearden et al. (2011) show that the introduction of up-front tuition fees and the abolition of maintenance grants in 1998 had a significant impact on participation rates in higher education in the UK. Also financial problems are cited as an important reason for dropping out of higher education for students from lower socio-economic backgrounds (Pennell & West, 2005).

When faced with needs in these dimensions, unless needs are forgone (remain unmet), people face greater expenses and/or loss of potential earning (since they trade off paid to unpaid work). As a result of this “financial effect” of having needs in missing dimensions, people might experience poverty, but this experience might not be captured by the deprivation scales. In other words, deprivation scales might be exposed to the missing dimensions problem. This is the main hypothesis called “financial effect” which will be tested to reveal the missing dimensions problem within deprivation scales: independent of deprivation status, having a higher need in missing dimensions affects poverty status through higher expenses and/or reduced potential earnings.

### **3. Perceived financial adequacy as a proxy of poverty and its drawbacks**

To examine the missing dimensions problem within deprivation scales, I use perceived financial adequacy as a proxy for poverty status. Similar measures are also used by Whelan & Maitre (2009; 2012) to validate new deprivation scales. Perceived financial adequacy shows respondent’s view on their ability to make ends meet (or manage financially).

This measure is ideal for the purposes here for mainly two reasons. First, it captures well the concept of poverty defined as relative deprivation. In this framework, poverty is defined as exclusion from the ordinary living patterns due to a lack of economic

resources (Townsend, 1979); in other words, poverty is related to an inability to meet certain material and social needs essential for serving expected societal roles such as citizens, workers, parents, friends, neighbours and relatives (Lister, 1990; Townsend, 1993). In a similar vein, while evaluating their own financial adequacy, individuals are expected to make a summary evaluation of the adequacy of their economic resources for satisfying their needs.

Secondly, as recently argued by Fusco (2016), perceived financial situation captures a much broader concept than low income as the former includes certain resources and needs not covered by the latter. The same is also relevant for deprivation scales. For example, while evaluating their own financial adequacy, individuals are expected to consider non-market goods such as access to care services or education as well as needs related to certain characteristics such as disability which are the aspects not covered by deprivation scales. Therefore perceived financial adequacy is a useful indicator to identify dimensions which are relevant to poverty but missing from the existing deprivation scales.

In this context, the idea is to examine the effect of having needs in missing dimensions on perceived financial adequacy while controlling for deprivation status. If having needs in certain dimensions affect financial adequacy independent of a deprivation measure, then there are dimensions which are relevant to poverty and affect poverty status yet are not covered by the deprivation measure – hence missing dimensions problem.

Nevertheless, using a self-assessed measure as a dependent variable has also some drawbacks. For example, the relationship between perceived financial adequacy and need factors might be confounded by some time-constant unobserved factors such as

scale heterogeneity and personality traits. People might have different interpretations of subjective welfare questions due to their personal frame-of-reference (Ravallion, 2012) or latent psychological factors such as personality traits affect how people respond to subjective welfare questions (Ravallion & Lokshin, 2001), and both of these issues might systematically vary with the need factors and cause overestimation of the effects of needs on poverty status.<sup>27</sup> To overcome these issues, the idea is to focus on within-individual variation over time using fixed effects as suggested by Ravallion (2012) and others (e.g. Pudney, 2008). Then the main question becomes whether a change in needs in missing dimensions triggers a change in the status of perceived financial adequacy controlling for the change in deprivation status.

The identification of the financial effect might however still be complex due to the subjective nature of the measure. The relationship between perceived financial adequacy and an indicator of need can still be confounded by various other dynamic factors. Three such biases are the following:

**State dependence.** Existing evidence shows state dependence in perceived financial adequacy – past status affects current status independent of the effect of changing circumstances (Fusco, 2016; Kaya, 2014). Pudney (2008) interprets such state dependence as a kind of inertia, where an individual’s perception is not simultaneously adjusted to changes in individual circumstances. Such state dependence can also be interpreted as a genuine scarring effect of poverty. Regardless of the interpretation, state dependence is a possible confounder for the relationship of interest and hence should be controlled for.

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<sup>27</sup> Scale heterogeneity therefore is assumed to be a time constant factor hence people are assumed to be consistent while evaluating the change in their self-assessment of their own financial situation.

**Negativity bias.** Self-assessment of one's financial situation is a cognitive judgement which requires the retrieval of information, mainly about past experiences. Psychological evidence shows that when making cognitive judgements, people consistently weight negative events more heavily than positive events (Kanouse, 1984; Baumeister et al., 2001; Rozin & Royzman, 2001). Thus due to this negativity bias, individuals might perceive their financial situation as insufficient especially after experiencing a situation of need in the household (e.g. having a new health problem, a newborn or a new student in the household), even if their objective financial conditions are not significantly worse.

**Anticipation.** When assessing their own financial situation, individuals might not only consider past experiences but also their future expectations, and a change in a need factor might alter future expectations while not having a significant effect on the current financial situation.

Therefore, due to state dependence, anticipation and/or psychological negativity bias, the effects of needs on perceived financial adequacy might be overestimated. In this context, the main aim is to identify the financial effect whilst controlling for these possible confounding effects. The analytical strategy for the identification of financial effect is explained in the following section.

#### **4. Data and methodology**

The data is British Household Panel Survey (BHPS), a representative longitudinal survey in the UK. I use a balanced sample from wave 9 to 18 (1999-2008) including every adult (16+) (4282 individual respondents per wave). This period is chosen to be able to use deprivation data starting at wave 6, and to utilize extension samples for Scotland and Wales included in the survey from wave 9 onwards. The unit of analysis is individual, but

as described below, some variables are constructed to represent the needs in the household. This choice depends on the assumption that individuals' financial adequacy is determined by the needs and resources in the household.<sup>28</sup>

The descriptive statistics for the employed variables are presented in Table 1. The dependent variable, perceived financial adequacy, is constructed as a binary variable for each individual respondent. The original question is the following: "How well would you say you yourself are managing financially these days? The answer categories are "living comfortably", "doing alright", "just about getting by", "finding it quite difficult" and "finding it very difficult". Those who find it quite difficult or very difficult to manage financially are defined as financially inadequate. The dependent variable is made binary to proxy a binary poverty status since as the variance above the poverty threshold is not of interest.

The deprivation index includes nine binary items.<sup>29</sup> The items (except durables and arrears) include an enforced criterion so show only households who say they are deprived due to affordability problems. The index is constructed as closely as possible to EU's 9-item material deprivation index; yet due to data limitations there are minor differences. Following common practice, a threshold of four is adopted – people who are deprived of four or more items are defined as (materially) deprived, but different thresholds are tested with similar results as presented in Supplementary Material. Table A1-A2 and Figure A1 in Appendix present the headcount rates over time, and

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<sup>28</sup> It also depends on the level of distribution of economic resources within the household. I aim to capture also this aspect given the individual nature of the dependent variable.

<sup>29</sup> The items are the following: ability to afford (1) keeping home adequately warm; (2) pay for annual holiday; (3) replace furniture; (4) buy new clothes; (5) eat meat on alternate days; (6) feed visitors once a month; and having (7) arrears on housing and loan payments; (8) a car; and (9) a washing machine.

correlations between financial adequacy and deprivation status (which is around 0.63 regardless of the deprivation threshold).

To operationalize the idea of missing dimensions, binary proxies that represent needs in the household in relevant dimensions are used. For health care, self-reported chronic health problems are used given that people with such problems are expected to have higher health care needs. Three such variables are having a person with heart or blood pressure problem in the household, having a person with diabetes in the household and having a person with depression or anxiety in the household. Similarly child care is operationalized as based on having a young child (aged 0-2) and paying for child care services in the household; social care is operationalized based on having a long-term caregiver in the household, having a disabled person in the household, and having a family caregiver (or unpaid worker) in the household; education need is operationalized based on having a child aged 5-11, 12-15, 16-18 and 19-24 in the household, and having an adult student in the household where the latter captures students aged older than 24. All these variables are taken to represent needs in the household, and hence expected to affect individuals' financial adequacy through higher expenses or reduced potential earnings.

To test the main financial mechanism hypothesis, two binary variables are used: i) more expenses, which indicates individuals who report having higher expenses as the main reason for becoming financially inadequate, and ii) reduced earnings, which shows individuals who report having reduced earnings as the main reason for becoming financially inadequate. To examine anticipation bias, I use a binary variable, future worse, which indicates individuals who expect a worse financial situation in the future.

For measuring personality, five-factor model traits are employed using 15 items included in the BHPS. Those traits are i) openness to experience relates to curiosity, flexibility and willingness to immerse oneself in atypical experiences; ii) conscientiousness regards planning, impulse control, responsibility and reliability; iii) extraversion concerns sociability, confidence and agency; iv) agreeableness describes friendliness, empathy and ability to inhibit negative feelings; and v) neuroticism refer to the ease and frequency with which a person becomes upset and distressed (Carver & Connor-Smith, 2010). The data for personality traits is drawn from wave 15 and is used as a time-invariant characteristic given the constancy of personality traits.<sup>30</sup> Each trait is represented by three variables, and with high reliability as shown by Nandi & Nicoletti (2014).<sup>31</sup> Each variable has a scale from 1 to 7. For each trait, measures are constructed as the average score of three relevant items (see Nandi & Nicoletti, 2014). The resulting scales are centred to have a range between 0 and 6 (for their use in interaction analysis).

As described in Table 1, control variables either represent household resources or various needs other than those categorized as missing dimensions. Income is operationalized as household disposable income, equivalized using the OECD scale and used in a log form. Education variable is seven category version of ISCED, reflecting the highest attained educational level (from 1=primary to 7=higher degree). Social class is operationalized based on Erikson-Goldthorpe five-category scheme (with a sixth category for those never worked). Other variables except household size are binary.

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<sup>30</sup> This is however clearly a limitation as there are also some psychological evidence showing the varying character of personality over time (Roberts et al., 2006)

<sup>31</sup> The variables used for each personality trait are as followed: Respondent see herself/himself as someone who (1) is original, comes up with ideas (2) values artistic, aesthetic experiences (3) has an active for *openness to experience*; who (1) does a thorough job (2) tends to be lazy (reversed) (3) does things efficiently for *conscientiousness*; who (1) is talkative (2) is outgoing, sociable (3) is reserved (reversed) for *extraversion*; who (1) is sometime rude to others (reversed) (2) has a forgiving nature (3) is considerate and kind for *agreeableness*; who (1) worries a lot (2) gets nervous easily (3) is relaxed, handles stress well (reversed) for *neuroticism*.

**Table 1: Descriptive statistics**

<b>Variable</b>	<b>Mean</b>	<b>Median</b>	<b>St. dev.</b>	<b>Min</b>	<b>Max</b>
Perceived financial adequacy	0.05	0	0.21	0	1
Deprivation status (4+)	0.02	0	0.12	0	1
<b>Health care need proxies</b>					
Heart/blood pressure prob. in HH	0.34	0	0.48	0	1
Diabetes prob. in HH	0.09	0	0.28	0	1
Depression/anxiety prob. in HH	0.13	0	0.34	0	1
<b>Child care need proxies</b>					
Child aged 0-2 in HH	0.06	0	0.23	0	1
Paid childcare in HH	0.03	0	0.17	0	1
<b>Social care need proxies</b>					
Long-term caregiver in HH	0.27	0	0.45	0	1
Disability in HH	0.06	0	0.25	0	1
Family caregiver in HH	0.11	0	0.32	0	1
<b>Education need proxies</b>					
Child aged 5-11 in HH	0.19	0	0.39	0	1
Child aged 12-15 in HH	0.11	0	0.32	0	1
Child aged 16-18 in HH	0.03	0	0.17	0	1
Child aged 19-24 in HH	0.09	0	0.28	0	1
Adult (16+) student in HH	0.08	0	0.27	0	1
<b>Financial mechanism</b>					
More expenses	0.02	0	0.13	0	1
Reduced earnings	0.01	0	0.09	0	1
Future worse	0.01	0	0.09	0	1
<b>Controls</b>					
Equiv. disp. HH income	16301	14418	9937	0	419276
Rented	0.16	0	0.36	0	1
Mortgage	0.48	0	0.50	0	1
Household size	3	2	1	1	8
Unemployed in HH	0.04	0	0.20	0	1
Divorced	0.05	0	0.23	0	1
Separated	0.01	0	0.10	0	1
Single parent	0.02	0	0.14	0	1
Educational attainment (ISCED)	3.53	3	1.75	1	7
Social class (EGP)	2.58	2	1.59	1	6
Openness (to experience)	3.40	3.33	1.19	0	6
Conscientiousness	4.31	4.33	1.07	0	6
Extraversion	3.41	3.33	1.18	0	6
Agreeableness	4.42	4.67	0.99	0	6
Neuroticism	2.58	2.67	1.30	0	6

*Notes: The statistics are presented for the total sample - in total 38205 respondents.*

Year, gender, age and age square are also included into the models. Missing data for each variable is usually below 3% as presented in Appendix (Table A3) which corresponds to in total 7% of the sample. The analysis is run on the non-missing sample.

#### 4.1. Analytical strategy

To account for various endogeneity problems related to using a subjective measure as a dependent variable, I estimate a correlated random-effect linear probability model (Wooldridge, 2010)<sup>32</sup>:

$$Pr(Y_{it}) = \alpha + X'_{it}\beta'_1 + C'_{it}\beta'_2 + \bar{X}'_i\delta'_1 + \bar{C}'_i\delta'_2 + Z'_i\gamma' + u_i + \varepsilon_{it}$$

In this model, Y is the poverty status measured by perceived financial adequacy, Xs are indicators of missing dimensions of need, Cs are time-varying controls, Zs are time invariant control variables such as gender and personality traits,  $u_i$  is the time constant unobserved variables and  $\varepsilon_{it}$  is the idiosyncratic error.

The main interest is in  $\beta'_1$  which show the effects of the changes in need factors on poverty status. This correlated random effect model allows us i) to control for the confounding effect of time constant unobserved heterogeneity ( $u_i$ ) such as personality traits and scale heterogeneity since the person-specific means ( $\bar{C}_i; \bar{X}'_i$ ) (or Mundlak terms) picks up any possible correlation between  $u_i$  and  $X'_{it}$ ; and, ii) to assess the negativity bias through the inclusion of interaction terms between need factors and certain personality traits (as explained below).

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<sup>32</sup> Linear probability is preferred to a logit specification as the main interest is on average marginal effect, which is not possible to consistently estimate using logistic models. Also, all the variables except income is binary which makes the use of linear probability model less problematic, especially in a longitudinal context. As discussed in sensitivity analysis, similar results in terms of significance are also reached when fixed effect logit is applied.

## 5. Results

As presented in Table 2, seven models are estimated to identify missing dimensions and financial effect mechanism. In the base model (Model 1), the missing dimensions hypothesis is examined based on the significance and effect sizes of need factors ( $\beta'_2$ ). The results show that increases in needs related to health care, child care, social care and education are statistically significantly and substantially increase the probability of poverty measured by perceived financial adequacy. For example, where the average predicted probability of poverty is around 5%, the increase in the probability of poverty by having someone in the household with diabetes is 2%, with depression or anxiety is 2.6%, with disability is 4.3%, by paying for childcare services is 2% and by having children aged 19-24 is 2.2%. These are substantively high numbers as also shown below based on predicted probabilities.

What explains these significant effects? In Model 2, deprivation status is included into the model to see to what extent the effects of needs ( $\beta'_2$ ) are captured by the deprivation index. The results do not change by the addition of binary deprivation index into the model hence the identified effects are independent of the deprivation status of individuals. In Model 3, state dependence bias is controlled for by adding a lagged dependent variable into the model, which only slightly reduces the effect of having a disabled person in the household.<sup>33</sup> In Model 4, future worse variable is included to control for anticipation bias, yet this also does not significantly affect the results. Only a third of the effect of having an adult student in the household is explained when future

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<sup>33</sup> In this and subsequent models, to account for initial condition problem, the value of the dependent variable in the first wave (wave 9) is included into the model (see Wooldridge, 2005). To have comparability between models, wave 9 is not included into the whole analysis except providing information for the initial condition term as well as lagged outcome.

**Table 2: Identifying the financial effect of having needs in missing dimensions on the probability of poverty – average marginal effects**

	<b>Model1</b>		<b>Model2</b>		<b>Model3</b>		<b>Model4</b>		<b>Model5</b>		<b>Model6</b>		<b>Model7</b>	
	<i>Base</i>		<i>Deprivation status</i>		<i>State dependence</i>		<i>Anticipation</i>		<i>More expenses</i>		<i>Reduced earnings</i>		<i>Financial effect</i>	
Deprivation status			0.169***	(0.022)	0.141***	(0.023)	0.108***	(0.021)	0.072***	(0.020)	0.095***	(0.020)	0.056**	(0.018)
Financial adequacy t-1					0.284***	(0.015)	0.238***	(0.014)	0.178***	(0.012)	0.212***	(0.013)	0.145***	(0.011)
Future worse							0.783***	(0.015)	0.345***	(0.026)	0.746***	(0.017)	0.270***	(0.026)
More expenses									0.729***	(0.014)			0.784***	(0.013)
Reduced earnings											0.806***	(0.015)	0.882***	(0.009)
<b>Health care need</b>														
Heart/blood prob. in HH	0.006	(0.004)	0.005	(0.004)	0.002	(0.004)	0.002	(0.003)	0.001	(0.003)	0.000	(0.003)	-0.001	(0.003)
Diabetes in HH	0.019*	(0.009)	0.020*	(0.009)	0.020*	(0.008)	0.018**	(0.007)	0.014*	(0.006)	0.018**	(0.006)	0.013**	(0.005)
Anxiety/depression in HH	0.024***	(0.005)	0.024***	(0.005)	0.022***	(0.005)	0.021***	(0.005)	0.015***	(0.004)	0.020***	(0.004)	0.013***	(0.004)
<b>Child care need</b>														
Child aged 0-2 in HH	0.011	(0.006)	0.010	(0.006)	0.007	(0.006)	0.010	(0.006)	0.008	(0.005)	0.004	(0.005)	0.002	(0.004)
Paid childcare in HH	0.020*	(0.010)	0.020*	(0.010)	0.020*	(0.009)	0.019*	(0.009)	0.019*	(0.008)	0.013	(0.008)	0.012	(0.007)
<b>Social care need</b>														
Long-term caregiver in HH	0.006	(0.003)	0.006	(0.003)	0.006	(0.003)	0.004	(0.003)	0.003	(0.003)	0.004	(0.003)	0.003	(0.002)
Disabled in HH	0.041***	(0.012)	0.038***	(0.012)	0.033**	(0.011)	0.034***	(0.010)	0.041***	(0.010)	0.007	(0.009)	0.013	(0.009)
Family caregiver in HH	0.011	(0.006)	0.011	(0.006)	0.010	(0.005)	0.008	(0.005)	0.007	(0.005)	0.004	(0.005)	0.003	(0.004)
<b>Education need</b>														
Child aged 5-11 in HH	-0.002	(0.006)	-0.002	(0.006)	-0.003	(0.006)	0.000	(0.005)	0.002	(0.005)	-0.000	(0.005)	0.002	(0.004)
Child aged 12-15 in HH	0.016*	(0.006)	0.016*	(0.006)	0.013*	(0.006)	0.012*	(0.005)	0.010*	(0.005)	0.011*	(0.005)	0.009*	(0.004)
Child aged 16-18 in HH	-0.013	(0.010)	-0.014	(0.010)	-0.017	(0.009)	-0.010	(0.009)	-0.008	(0.008)	-0.001	(0.008)	0.002	(0.007)
Child aged 19-24 in HH	0.020**	(0.006)	0.018**	(0.006)	0.015**	(0.005)	0.014**	(0.005)	0.006	(0.005)	0.015**	(0.005)	0.006	(0.004)
Adult student in HH	0.019*	(0.008)	0.019*	(0.008)	0.019**	(0.007)	0.014*	(0.007)	0.011	(0.006)	0.006	(0.006)	0.002	(0.005)
N	38538		38538		38538		38538		38538		38538		38538	

Notes: \*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ . The table shows the results of different specifications of a correlated random effect linear probability model described in methods section. The coefficients are average marginal effects. The dependent variable is perceived financial adequacy. The models include controls related to various other resources and needs such as income, house tenure, household size, unemployed in the household, marital status, educational attainment and social class as well as other controls such as time period, age, age square, gender and personality traits. From Model 3, the models also include an initial condition variable. The full results are presented in Supplementary Material. The results show the significant effects of missing dimensions on perceived financial adequacy even after controlling for deprivation status explained by financial mechanism and not by state dependence and anticipation.

worse is included into the model. Therefore, the effects are still unexplained after controlling for deprivation status, state dependence and anticipation biases.

In Model 5, 6 and 7, the variables related to financial mechanism are included to see to what extent the effects of needs  $\beta'_2$  are explained by the hypothesized financial mechanism. In model 5, more expenses, in Model 6, reduced earnings and finally in Model 7, both variables are included in the model.

Model 5 shows that a significant part of the explanation is related to having higher expenses. Including the variable of more expenses explain a quarter of the effects of having a person with diabetes and having a person with depression/anxiety in the household and more than half of the effect of having a child aged 12-15 and having a child aged 19-24 in the household. As shown in Model 6, another significant factor explaining the identified effects is having reduced earnings. Including reduced earnings to the model explains almost all of the effect of having a disabled person in the household as well as the effect of paying for childcare services (also half of the effect of having a young child in the household). Adding both more expenses and reduced earnings, as done in Model 7, explains almost all of the effects of needs on poverty, except some of the effects of having a person with diabetes and a person with anxiety/depression in the household.<sup>34</sup>

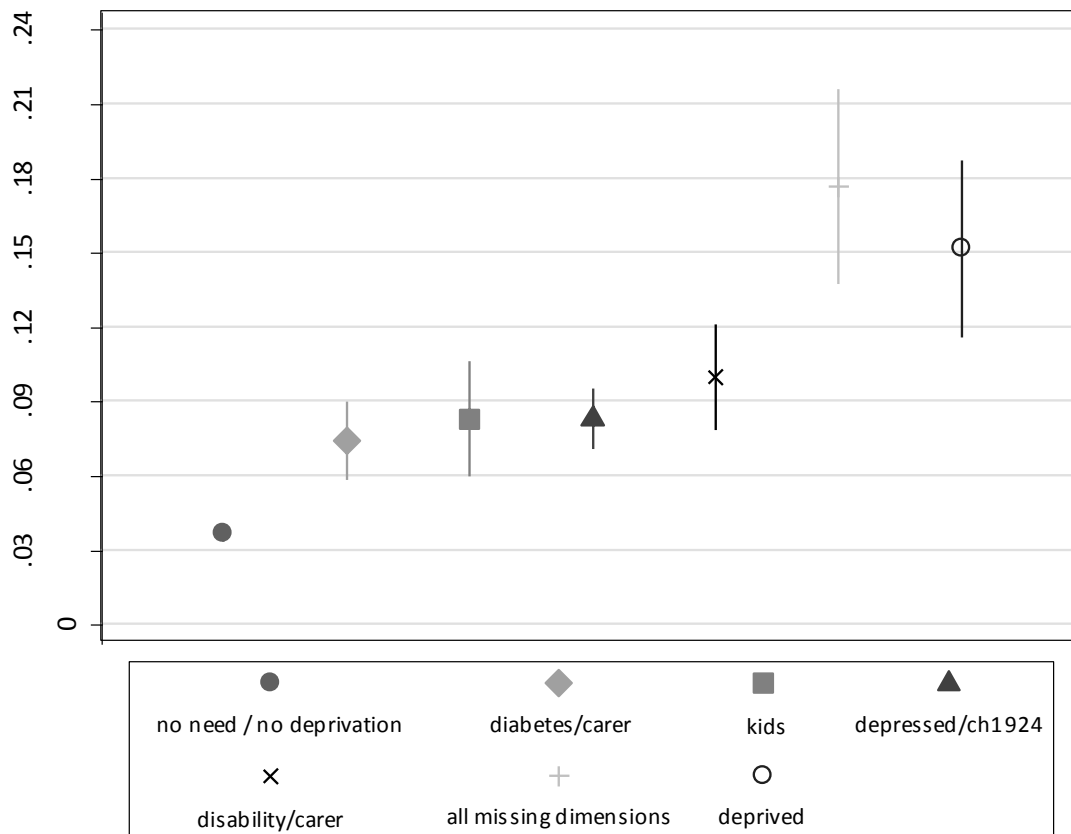
These findings support the claim that having needs in these missing dimensions affect poverty status independent of deprivation status mainly due to having more expenses and/or loss of earnings. In other words, people who have needs in missing dimensions might be experiencing poverty but not be captured by the deprivation index.

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<sup>34</sup> One explanation for these remaining effects can be reverse causality.

But how big is the probability that people with needs in missing dimensions experience poverty? To examine this, predicted probability of poverty is estimated for different individual profiles based on Model 4. The idea is to see the extent to which an individual who is identified as non-deprived but has various needs in missing dimensions has a comparable probability of poverty to an individual who is identified as deprived.

**Figure 1: Predicted probability of poverty for deprived vs. non-deprived with needs in missing dimensions**



Notes: The graph shows predicted probability of poverty for some typical individual profiles. The estimations are based on Model 4. The results show that having needs in missing dimensions increases one's risk of poverty as much as material deprivation does. The typical individual profiles are as following: **no need/not deprived**: living in a household with no missing need and not deprived; **diabetes/carer**: living with a family caregiver and someone with a diabetes; **kids**: living with a child aged 0-2 and a child aged 12-15 and using paid child care services; **depressed/ch1924**: living with a person with depression/anxiety and a child aged 19-24; **disability/carer**: living with a disabled person, a family caregiver and long-term caregiver; **all missing needs**: living in a household with all needs that are statistically significant in Model 4; **deprived**: materially deprived.

As shown in Figure 1, the probability of poverty for an individual who has no needs in missing dimensions and is not identified as materially deprived is in average 3.7%, which increases to around 9% for an individual who is not deprived but living in a household with a child aged 0-2 and a child aged 12-15 and uses paid child care services<sup>35</sup>; and, to around 10% for an individual who is not deprived but living in a household with a disabled person and a family caregiver. The probability of poverty is 15% for individuals who are only materially deprived, while it is around 18% in a household with needs in all missing dimensions (significant effects in Model 4).

Therefore, i) having needs in missing dimensions significantly increases the probability of poverty compared to those without needs, especially in situations where multiple needs intersect; and ii) having needs in missing dimensions increases one's risk of poverty as much as deprivation does for those identified as materially deprived.

### 5.1. *Psychological negativity bias?*

To what extent are the identified effects overestimated due to the psychological negativity bias? After experiencing needs, individuals might give greater weight to these “negative” events hence might be more likely to perceive their financial situation as worse than it actually is. Such negativity bias could not be examined in the applied models as it is a time-varying unobserved factor. Still, the extent of negativity bias can be explored *post hoc* by examining to what extent the identified effects vary among individuals with different levels of neuroticism and conscientiousness.

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<sup>35</sup> The probability of poverty is also around 9% for those living in a household with a caregiver and a person with diabetes; also for those living in a household with a person with depression or anxiety and a child aged 19-24.

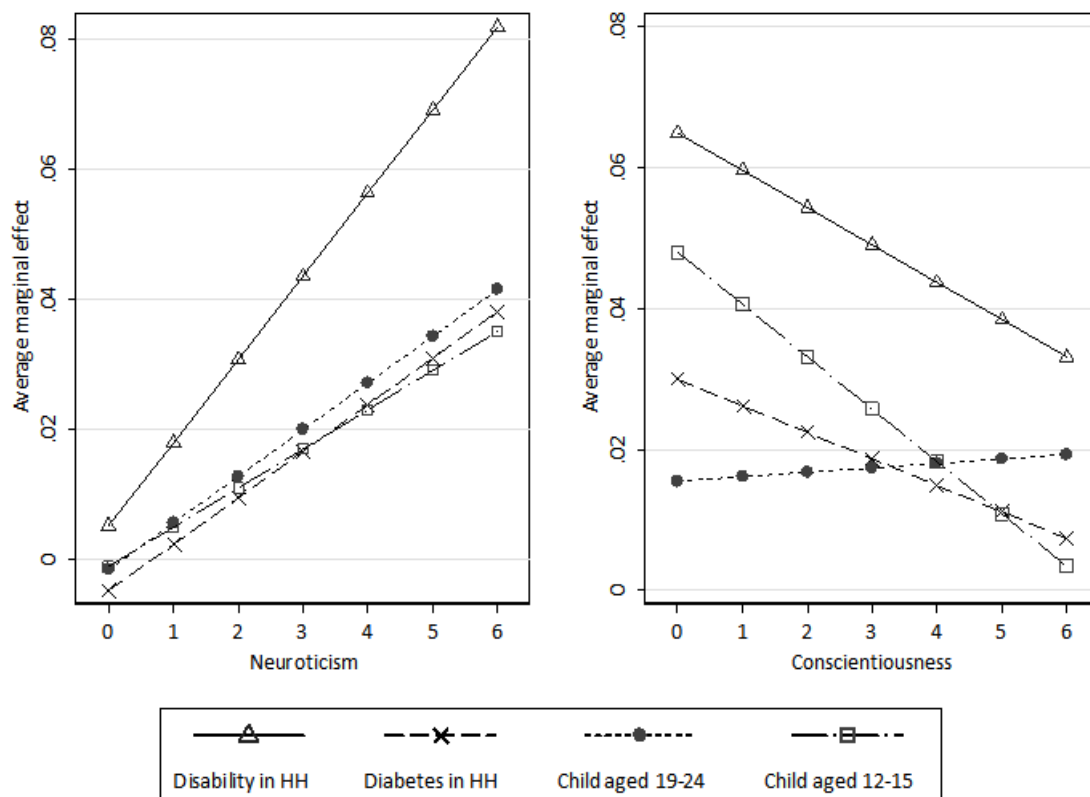
Neuroticism is generally defined as the propensity to experience negative emotions (Ormel et al., 2013). Individuals high on neuroticism tend to perceive events as having a greater impact on their lives (Benishkek & Lopez, 1997) and highly threatening, while perceiving their own coping resources as low (Carver & Connor-Smith, 2010), either due to emotional reactivity or due to cognitive processing of emotional information (Diener et al. 2003). Therefore, if there is a negativity bias, one would expect its impact to be greater for people high on neuroticism. In other words, after facing needs in the household, people high on neuroticism, *ceteris paribus*, should be more likely to say that they are financially insufficient if there is a psychological negativity bias.

To examine this, the interactions between the identified significant effects and neuroticism are separately added to the Model 2. As shown in Table A4 in Appendix, none of the interaction terms are statistically significant; however, despite being statistically not significant, the effect sizes of interactions between neuroticism, and having a person with diabetes in the household, having a person with depression/anxiety in the household and having a child aged 19-24 and 12-15 are substantively high.

Figure 2 presents the change in average marginal effects of these variables across people with different levels of neuroticism. For example, the effect of having a person with diabetes in the household is around 0.08 for the people with highest neuroticism while it is around zero for the people with lowest neuroticism. Similarly, for other three variables, the effect sizes are around zero for the people with lowest neuroticism. Given that we expect for the people with lowest neuroticism to be less prone to a negativity bias, these results might be showing that the identified significant effects for these four variables are spurious and overestimated due to a negativity bias.

However, the greater effects for highly neurotic people might not be explained solely by negativity bias but also by their behavioral responses— for example, their budgeting behavior. People high on neuroticism tend to be inefficient coping with negative events, do less money management, have a lower ability to control urges, and thus are more likely to have higher debt and more instances of compulsive buying (Donnelly et al., 2012; Ormel et al., 2013). So, the greater effects for highly neurotic people can also be explained by their ineffective behavioral responses to having needs. How can we distinguish negativity bias from the effect of behavioral responses?

**Figure 2: Investigating the psychological negativity bias in the effects of needs**



Notes: The figure shows the average marginal effects for four identified effect across different levels of neuroticism and conscientiousness. The models are applied for the specification in Model 2. The results are presented in Appendix.

The effect of behavioral response can be detected by observing the heterogeneity of effects among people with different levels of conscientiousness. People high on conscientiousness are shown to be better at money management (e.g. with less debt, more savings and less prone to compulsive and impulsive buying) as a result of their higher ability to self-control, delay gratification, planning and deliberation (Donnelly et al. 2012; Roberts et al. 2014). Thus if there is a behavioral response effect, one would expect the effects of needs on poverty status be lower for the people high on conscientiousness.

To examine this, the interactions between the four effects (identified above as varying with neuroticism) and conscientiousness are separately added to the Model 2. Although none of the interaction effects are statistically significant (see Table A4 in Appendix for the results), the effects of three needs (e.g. disability, diabetes and a child aged 12-15 in the household) are substantively lower for the people with higher conscientiousness. Especially for having a person with diabetes in the household and having a child aged 19-24 in the household, the effects are very close to zero for the people with highest conscientiousness (see Figure 2). Yet, the effect of having a child aged 19-24 in the household is not different among the people with different level of conscientiousness, hence shows no variations due to behavioral response.

These findings show that except for the variable of having a child aged 19-24 in the household, the heterogeneity in effects due to neuroticism is likely to be a result of varying behavioral responses rather than a negativity bias. For having a child aged 19-24 in the household, the identified effect is likely to be overestimated due to a negativity bias.

## 6. Sensitivity analysis

To assess the robustness of the findings, I have conducted various sensitivity analyses, whose results are presented in the Supplementary Material. The analysis is repeated with substantively the same results using different thresholds for the deprivation index (3+, 2+, 1+), and using three separate dimensions of deprivation (altogether) such as basic needs, social activities and durables (see Table A1-A5). Therefore, the issue seems to be unrelated to the specification of the threshold and the index given a fixed set of indicators.

Also, the analysis is repeated for two other measures which combines deprivation and income poverty measures using two approaches (see Table A6-A7). The first is the intersection approach (consistent poverty approach) as used in UK's child poverty measure, which defines people in poverty as those who is identified by both the deprivation measure and a relative income poverty measure (60% of median). The second is the union approach as used in the EU's poverty target, which defines people in poverty as those who are identified by either of the two measures. The results are again exactly the same. So combining income and deprivation scales, using intersection or union approach, does not provide a solution to the missing dimensions problem (as expected given the model include household income).

To also test the direction and temporality of the identified effects, I include lags of each variable to the model (see Table A8). Only two of the lags (among the identified need factors) have statistically significant effects, namely having a person with diabetes in the household and having a person with depression or anxiety in the household. For both variables (and for paid childcare in the household despite the lag is not statistically

significant), the total size of current and lag terms is greater than the size of the effect in the main model, which shows that i) the effect in the main model partly represent the effects from the previous year, and ii) these variables have long-term effects in addition to their instantaneous effects. These findings ensure that the direction of the association is, at least partly, from health to poverty status.

Another issue may be the unit of analysis, as individuals within the same households might report different levels of perceived financial adequacy. To examine this, the main model is run separately for men and women (see Table A9-A10). Three interesting differences between men and women are observed.<sup>36</sup> First, the effect size of deprivation on poverty status is almost double for women than men. Therefore, the deprivation scale explains financial situation much better for women than men. Secondly, the effect of having paid childcare services for men is zero while it is strong and statistically significant for women; also the effects of having a disabled person in the household and having an adult student in the household are much stronger for women than men. These findings might show unequal allocation of resources within households or that the financial cost of having dependent members in the household bear more on women than men. Indeed, De Henau & Himmelweit (2013) show that child-care costs usually bear on women's and not men's earnings. However, and thirdly, the effect of having a child aged 0-2 and having a family caregiver in the household is much stronger for men than women, which might related to the differential evaluation of financial conditions due to varying information about overall household budget.

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<sup>36</sup> There are also other differences in terms of statistical significance, yet it is mostly a result of standard error since the effects sizes are very close between men and women.

## 7. Conclusion

This article questioned whether summary deprivation indices with a limited set of items accurately identify people in poverty. The analysis has shown that independent of the deprivation status, having needs in health care, child care, social care and education substantially increases the probability of being in poverty as needs in these dimensions either incur extra spending or limit the earnings potential. In some cases, the individuals with needs in certain missing dimensions have the same probability of poverty as the individuals who are identified as materially deprived. In other words, individuals who have needs in missing dimensions might experience poverty without being identified by a deprivation index. Moreover, the groups who potentially are missed by the deprivation scales are likely to be the risk groups such as single parents, those with a serious health problem or with many caring responsibilities. Therefore, similar to the findings of Beduk (2016), the empirical analysis here does not provide supporting evidence on the main assumption of deprivation scales – using a limited set of items, deprivation scales might systematically be missing some people in poverty. To improve measurement, indicators showing cost-related unmet need in these missing dimensions should be included into the indices.

The analysis here is focused on the UK, but a similar picture albeit with some variance can be expected for other EU countries. Among the EU countries, the UK has one of the lowest levels of cost-related access problems in health care as the National Health System (NHS) is unique in its low level of cost sharing (Robertson et al., 2014; Schokkaert et al., 2017). If health care problems such as heart and blood pressure, anxiety and depression substantively increase the probability of poverty (after controlling for the deprivation index) even in the UK, one would expect the financial impact of health

problems to be more pronounced in other EU countries considering the higher levels of out-of-pocket payments on medical goods and services. Also for care services, despite the lack of universal access in the UK, the financial burden borne by households is no less in most EU countries. For example, Ranci & Pavolini (2015) argue for Western European countries that following the onset of the financial crisis, the movement towards universalism in long-term care was reduced and often reversed towards marketization or refamilization of care provision mainly due to concerns related to cost-containment. Similarly for child care, around the EU (except Nordic countries), mothers face a “child penalty” (Flynn, 2017), where for example around 50% of women not working or working part time say that they do not work full-time because the child care is too expensive (Mills et al., 2014). For the education dimension, however, one would expect costs to be less of a problem for other EU countries, as from primary to tertiary, tuition fees are either nonexistent or significantly lower compared to the UK; still high subsidies and loans also help to compensate the cost of education in the UK (Garritzmann, 2015).

The missing dimensions problem has important implications for the evaluation of relevant policies and performance of welfare states. Current deprivation scales might not be as sensitive as they should be to impact of relevant policies, mostly regarding services related to health care, child care and social care. For example, the distributional impact of more private provision and financing of these services cannot be directly captured by deprivation scales unless they include an indicator related to cost-related access problems (cf. Seeleib-Kaiser, 2008). Moreover, beyond specific policy domains, poverty as an outcome indicator is also commonly used to assess the performance of welfare states and when summary deprivation indices are used, the service dimension of welfare states might be largely overlooked, despite being a crucial part of the analysis,

especially in the wake of a shift in risks and responsibilities towards families (Brennan et al., 2012; Ranci & Pavolini, 2015).

A long-standing issue in poverty measurement is how to account in-kind benefits and varying needs in non-market goods such as health, care and education (e.g. Marx et al., 2013). Despite a broad consensus on the need to include such dimensions, they have largely been discarded from the main analyses of income poverty measures and sometimes evaluated only ex post – how much does accounting for public services change the estimates of poverty? The answers usually show that accounting for public services makes a significant impact on income poverty rates (*inter alia* Aaberge et al., 2013). In this article, I have shown that the same problem might also be relevant for deprivation scales; the solution, however, is easier. Two main difficulties in accounting for non-market goods while evaluating poverty using income are i) valuation of non-market goods, and ii) adjustment for varying needs in these non-market goods. Including relevant deprivation indicators such as cost-related unmet needs in health care, child care, social care and education in the deprivation indices has the potential to overcome both of these difficulties and provide a solution to the problem of missing dimensions.

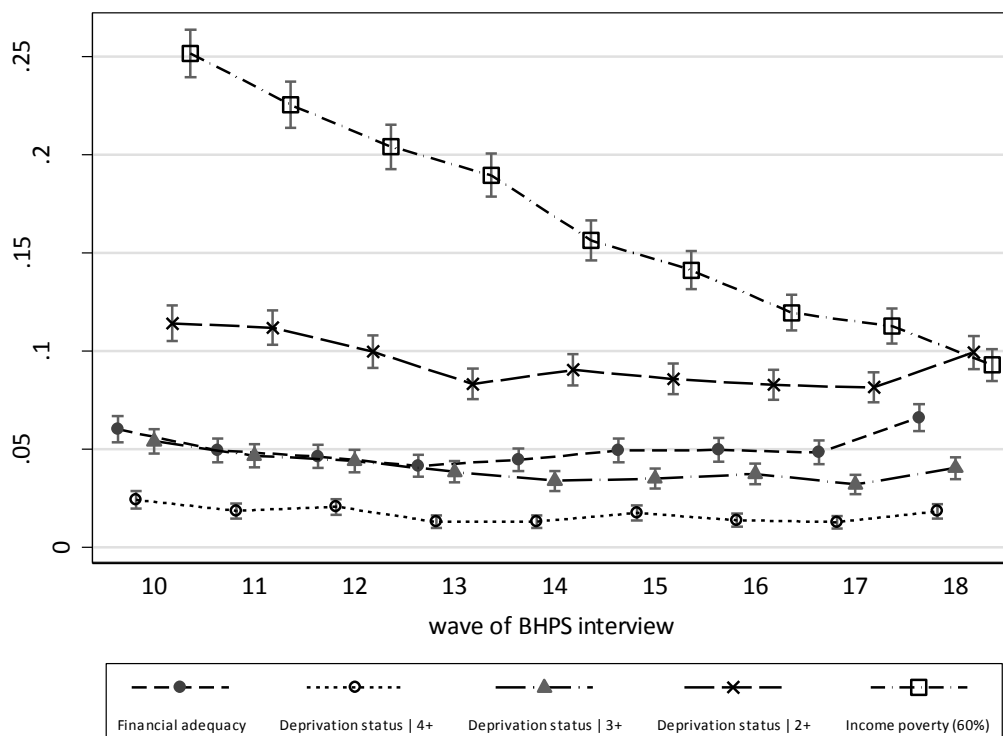
## 8. Appendix

**Table A1: Poverty headcount rates over time for different measures**

Wave	Financial adequacy	Deprivation status  4+	Deprivation status  3+	Deprivation status  2+	Income poverty (60%)
9	0.063	0.025	0.056	0.119	0.242
10	0.058	0.021	0.048	0.106	0.209
11	0.047	0.017	0.042	0.101	0.190
12	0.043	0.018	0.038	0.091	0.166
13	0.038	0.012	0.033	0.074	0.148
14	0.042	0.011	0.030	0.084	0.124
15	0.046	0.015	0.030	0.078	0.110
16	0.046	0.012	0.033	0.075	0.089
17	0.046	0.011	0.029	0.075	0.084
18	0.064	0.017	0.038	0.094	0.069
Total	0.049	0.016	0.038	0.090	0.143

Notes: The table shows the poverty rates for different indicators such as financial adequacy, deprivation scales with different thresholds and a relative income poverty measure (60% of median household equivalized disposable income).

**Figure A1: Poverty rates over time for different measures**



Notes: The figure shows the poverty headcounts for different indicator such as financial adequacy, deprivation scales with different thresholds and a relative income poverty measure (60% of median household equivalized disposable income) for the sample of 4532 adults over the period between 1999 and 2008. The estimates are not weighted.

**Table A2: Correlation between different measures of poverty**

	Financial adequacy	Deprivation status   4+	Deprivation status  3+	Deprivation status  2+	Income poverty (60%)
Financial adequacy	1				
Deprivation status 4+	0.6275	1			
Deprivation status 3+	0.6278	1	1		
Deprivation status 2+	0.5909	1	1	1	
Income poverty (60%)	0.2854	0.4739	0.4695	0.4772	1

**Table A3: Missing data**

Variables	Missing cases	Sample size	Missing rate
Perceived financial adequacy	47	47324	0.001
Paid childcare in HH	19	47324	0.000
Long-term caregiver in HH	701	47324	0.015
Income	64	47324	0.001
Rented	72	47324	0.002
Mortgage	72	47324	0.002
Educational attainment	113	47324	0.002
Social class	630	47324	0.013
Openness (to experience)	1,138	47324	0.024
Conscientiousness	1,083	47324	0.023
Extraversion	931	47324	0.020
Agreeableness	905	47324	0.019
Neuroticism	843	47324	0.018
Total	3403	47324	0.072

**Table A4: Examining potential psychological negativity bias in the effects of needs**

	<b>Model 8</b>		<b>Model 9</b>		<b>Model 10</b>		<b>Model 11</b>		<b>Model 12</b>		<b>Model 13</b>		<b>Model 14</b>	
Neuroticism (NE)	0.006***	(0.002)	0.004**	(0.002)	0.004**	(0.001)	0.006***	(0.002)	0.004**	(0.002)	0.006***	(0.002)	0.006***	(0.002)
Diabetes	-0.005	(0.020)												
Diabetes * NE	0.007	(0.009)												
Anxiety/dep.			0.016	(0.012)										
Anxiety/dep * NE			0.004	(0.004)										
Disability					0.005	(0.023)								
Disability * NE					0.013	(0.008)								
Child 19-24							-0.002	(0.011)						
Child 19-24 * NE							0.007	(0.004)						
Child 12-15									-0.001	(0.013)				
Child 12-15 * NE									0.006	(0.005)				
Adult student											0.024*	(0.012)		
Adult student * NE											-0.004	(0.005)		
Childcare													0.014	(0.024)
Childcare * NE													-0.000	(0.008)
	<b>Model 15</b>		<b>Model 16</b>		<b>Model 17</b>		<b>Model 18</b>							
Conscientious. (CO)	-0.004*	(0.002)	-0.003	(0.002)	-0.002	(0.002)	-0.002	(0.002)						
Diabetes	0.030	(0.039)												
Diabetes * CO	-0.004	(0.009)												
Disability			0.065	(0.037)										
Disability * CO			-0.005	(0.008)										
Child 19-24					0.016	(0.029)								
Child 19-24 * NE					0.001	(0.006)								
Child 12-15							0.048	(0.029)						
Child 12-15 * NE							-0.007	(0.006)						

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**9. Supplementary material for “Missing dimensions: Calibrating deprivation scales using perceived financial adequacy”**

## **S1. Sensitivity analyses**

The table S1 shows the results of a correlated random effect linear probability model described in methods section. The coefficients are average marginal effects. The dependent variable is perceived financial adequacy. The models include controls related to various other resources and needs such as income, house tenure, household size, unemployed in the household, marital status, educational attainment and social class as well as other controls such as time period, age, age square, gender and personality traits. Also, the models include lagged dependent variable to control for state dependence and an initial condition variable, and future worse variable to control for anticipation. Dimensional deprivations are constructed as binary variables. Basic needs deprivation is defined as having enforced deprivation of food, fuel or clothing. Comfort and social activities deprivation is defined as having enforced deprivation of holiday, furniture or meeting friends and relatives. Lastly, durables deprivation is defined as having a lack of at least four of the following items: tv, vcr, washing machine, dishwasher, microwave, cd player, computer and car.

The results demonstrate that the conclusions are independent of the specification of the index; also, combining deprivation scales with income measures, either with intersection or union approach, also does not solve the missing dimensions (as would have been expected given that the model household income as a control).

**TableS1: Testing different specification of deprivation index - thresholds, dimensionality, and combinations with income**

	<b>ModelB1</b>		<b>ModelB2</b>		<b>ModelB3</b>		<b>ModelB4</b>		<b>ModelB5</b>		<b>ModelB6</b>		<b>ModelB7</b>	
	<i>Deprivation status cut-off=3 (4+)</i>		<i>Deprivation status cut-off=2 (3+)</i>		<i>Deprivation status cut-off=1 (2+)</i>		<i>Deprivation status cut-off=0 (1+)</i>		<i>Dimensions</i>		<i>Intersection</i>		<i>Union</i>	
Deprivation status   3	0.108***	(0.021)												
Deprivation status   2			0.121***	(0.013)										
Deprivation status   1					0.078***	(0.009)								
Deprivation status   0							0.055***	(0.006)						
<i>Dimensions</i>														
Basic needs									0.073***	(0.014)				
Social activities									0.053***	(0.007)				
Durables									0.009	(0.007)				
Intersection with income											0.099***	(0.018)		
Union with income													0.007	(0.005)
<b>Health care need</b>														
Heart/blood prob. in HH	0.002	(0.003)	0.003	(0.003)	0.003	(0.003)	0.002	(0.003)	0.002	(0.003)	0.003	(0.003)	0.002	(0.003)
Diabetes in HH	0.018**	(0.007)	0.016*	(0.007)	0.017*	(0.007)	0.018*	(0.007)	0.017*	(0.007)	0.017*	(0.007)	0.018*	(0.007)
Anxiety/depression in HH	0.021***	(0.005)	0.021***	(0.005)	0.020***	(0.005)	0.021***	(0.005)	0.021***	(0.005)	0.021***	(0.005)	0.021***	(0.005)
<b>Child care need</b>														
Child aged 0-2 in HH	0.010	(0.006)	0.010	(0.006)	0.009	(0.006)	0.009	(0.006)	0.009	(0.006)	0.010	(0.006)	0.010	(0.006)
Paid childcare in HH	0.019*	(0.009)	0.019*	(0.009)	0.019*	(0.009)	0.020*	(0.009)	0.019*	(0.009)	0.019*	(0.009)	0.019*	(0.009)
<b>Social care need</b>														
Long-term caregiver in HH	0.004	(0.003)	0.004	(0.003)	0.004	(0.003)	0.004	(0.003)	0.004	(0.003)	0.004	(0.003)	0.004	(0.003)
Disabled in HH	0.034***	(0.010)	0.034***	(0.010)	0.034***	(0.010)	0.034***	(0.010)	0.032**	(0.010)	0.034***	(0.010)	0.035***	(0.010)
Family caregiver in HH	0.008	(0.005)	0.006	(0.005)	0.006	(0.005)	0.006	(0.005)	0.005	(0.005)	0.007	(0.005)	0.009	(0.005)
<b>Education need</b>														
Child aged 5-11 in HH	0.000	(0.005)	0.001	(0.005)	-0.001	(0.005)	-0.001	(0.005)	0.000	(0.005)	0.000	(0.005)	0.002	(0.005)
Child aged 12-15 in HH	0.012*	(0.005)	0.012*	(0.005)	0.010	(0.005)	0.010	(0.005)	0.011*	(0.005)	0.013*	(0.005)	0.012*	(0.005)
Child aged 16-18 in HH	-0.010	(0.009)	-0.012	(0.008)	-0.012	(0.008)	-0.011	(0.009)	-0.011	(0.008)	-0.010	(0.009)	-0.010	(0.009)
Child aged 19-24 in HH	0.014**	(0.005)	0.012*	(0.005)	0.013*	(0.005)	0.014**	(0.005)	0.013*	(0.005)	0.014**	(0.005)	0.015**	(0.005)
Adult student in HH	0.015*	(0.007)	0.014*	(0.007)	0.013	(0.007)	0.012	(0.007)	0.012	(0.007)	0.014*	(0.007)	0.014*	(0.007)
N	38538		38538		38538		38538		38538		38538		38538	

Notes: \*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .

In Table S2, to also test the direction and temporality of the identified effects, I include lags of each variable to the model (see Table S2, model B9). Only two of the lags (among the identified need factors) have statistically significant effects, namely having a person with diabetes and having a person with depression or anxiety in the household. For both variables (and for paid childcare in the household despite the lag is not statistically significant), the total size of current and lag terms is greater than the size of the effect in the main model, which shows that i) the effect in the main model partly represent the effects from the previous year, and ii) these variables have long-term effects in addition to their instantaneous effects. These findings ensure that the direction of the association is, at least partly, from health to poverty status.

Another issue may be the unit of analysis, as individuals within the same households might report different levels of perceived financial adequacy. To examine this, the main model is run separately for men and women (see Table S2, B10-B11). Three interesting differences between men and women are observed.<sup>37</sup> First, the effect size of deprivation on poverty status is almost double for women than men. Therefore, deprivation index explain financial situation much better for women than men. Secondly, the effect of having paid childcare services for men is zero while it is strong and statistically significant for women; also the effects of having a disabled person in the household and having an adult student in the household are much stronger for women than men. These findings might show unequal allocation of resources within households or that the financial cost of having dependent members in the household bear more on women than men. Indeed, De Henau & Himmelweit (2013) show that child-care costs usually bear on women's and not men's earnings. However, and thirdly, the effect of having a child aged

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<sup>37</sup> There are also other differences in terms of statistical significance, yet it is mostly a result of standard error since the effects sizes are very close between men and women.

0-2 and having a family caregiver in the household is much stronger for men than women, which might related to the differential evaluation of financial conditions due to varying information about overall household budget.

**Table S2: Random effect logit model & models with lagged variables, and for women and men**

	<b>ModelB1</b> <i>Deprivation status</i> <i>LPM-marginal effect</i>		<b>ModelB8</b> <i>Random effect Logit</i> <i>log odds</i>		<b>ModelB9</b> <i>Lags</i> <i>LPM-marginal effect</i>		<b>ModelB10</b> <i>Female</i> <i>LPM-marginal effect</i>		<b>ModelB11</b> <i>Male</i> <i>LPM-marginal effect</i>	
Deprivation status	0.169***	(0.022)	1.146***	(0.167)	0.165***	(0.025)	0.212***	(0.029)	0.102**	(0.034)
<b>Health care need</b>										
Heart/blood prob. in HH	0.005	(0.004)	0.103	(0.106)	0.005	(0.004)	0.007	(0.005)	0.003	(0.005)
Diabetes in HH	0.021*	(0.009)	0.580*	(0.239)	0.008	(0.009)	0.021	(0.013)	0.019	(0.012)
Anxiety/depression in HH	0.024***	(0.005)	0.494***	(0.106)	0.021***	(0.005)	0.024***	(0.007)	0.024**	(0.007)
<b>Child care need</b>										
Child aged 0-2 in HH	0.011	(0.006)	0.273	(0.167)	0.008	(0.007)	-0.001	(0.009)	0.021*	(0.009)
Paid childcare in HH	0.020*	(0.010)	0.572*	(0.273)	0.015	(0.011)	0.023*	(0.010)	-0.016	(0.025)
<b>Social care need</b>										
Long-term caregiver in HH	0.006	(0.003)	0.200*	(0.099)	0.005	(0.003)	0.003	(0.005)	0.009*	(0.004)
Disabled in HH	0.039***	(0.012)	0.694***	(0.186)	0.042***	(0.012)	0.045**	(0.016)	0.031	(0.017)
Family caregiver in HH	0.011	(0.006)	0.301*	(0.140)	0.009	(0.006)	0.003	(0.008)	0.019*	(0.008)
<b>Education need</b>										
Child aged 5-11 in HH	-0.002	(0.006)	-0.018	(0.149)	-0.003	(0.008)	-0.006	(0.009)	0.000	(0.008)
Child aged 12-15 in HH	0.016*	(0.006)	0.408**	(0.139)	0.024**	(0.008)	0.020*	(0.009)	0.011	(0.008)
Child aged 16-18 in HH	-0.014	(0.010)	-0.291	(0.206)	-0.006	(0.010)	-0.025	(0.014)	-0.001	(0.012)
Child aged 19-24 in HH	0.018**	(0.006)	0.425**	(0.140)	0.010	(0.007)	0.018*	(0.009)	0.019*	(0.008)
Adult student in HH	0.019*	(0.008)	0.375*	(0.152)	0.021*	(0.008)	0.026*	(0.011)	0.013	(0.011)
<b>Lags</b>										
L.Heart/blood prob. in HH					0.000	(0.004)				
L.Diabetes in HH					0.019*	(0.008)				
L.Anxiety/depression in HH					0.013*	(0.005)				
L.Child aged 0-2 in HH					0.004	(0.007)				
L.Paid childcare in HH					0.021	(0.012)				
L.Long-term caregiver in HH					0.003	(0.004)				
L.Disabled in HH					0.004	(0.011)				
L.Family caregiver in HH					-0.011	(0.006)				
L.Child aged 5-11 in HH					-0.005	(0.007)				
L.Child aged 12-15 in HH					-0.006	(0.007)				
L.Child aged 16-18 in HH					-0.019*	(0.010)				
L.Child aged 19-24 in HH					0.011	(0.006)				
L.Child aged 5-11 in HH					-0.001	(0.007)				
N	38538		38538		34256		19791		18747	

Notes: \*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .

### **Paper 3:**

#### **Are zeros distinct?**

#### **Understanding the risk and the level of material deprivation for 25 EU countries**

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## **Abstract**

In this article, I hypothesize and test whether scoring zero on a material deprivation index is a qualitatively different phenomenon to scoring at least one by applying and comparing multiple count models. I then examine how neglecting the distinctiveness of zeros, as the case in conventional models, influences our understanding of deprivation risk (deprived vs. non-deprived) and deprivation level (high vs. low deprivation), specifically regarding their relationship to social class. Consistently across 25 EU countries, the findings show that those with zero deprivation have significantly distinct profiles to those who have at least one deprivation. These results are robust to different weighting and index specifications. I then demonstrate how neglecting the distinctiveness of zeros results in significant underestimation of the strong social class gradient in risk of deprivation, and significant overestimation of the rather weak social class gradient in level of deprivation. Moreover, accounting for the distinctiveness of zeros reveals the conceptual difference between the risk and the level of deprivation given their different determinants while conventional models identify the same determinants for both. These findings are broadly consistent across 25 EU countries, with some exceptions in countries with very low level of zeros such as Hungary, Bulgaria and Romania. Relevant scales with a zero threshold can be used to study deprivation or to measure poverty in the EU yet either with some reconsiderations of conceptual and data problems or using a consistent poverty approach.

**Keywords:** determinants of material deprivation; deprivation threshold; zero deprivation; risk of deprivation; level of deprivation; social class gradient in deprivation; zeros vs. counts; risk vs. level of deprivation; count data models; hurdle models

## 1. Introduction

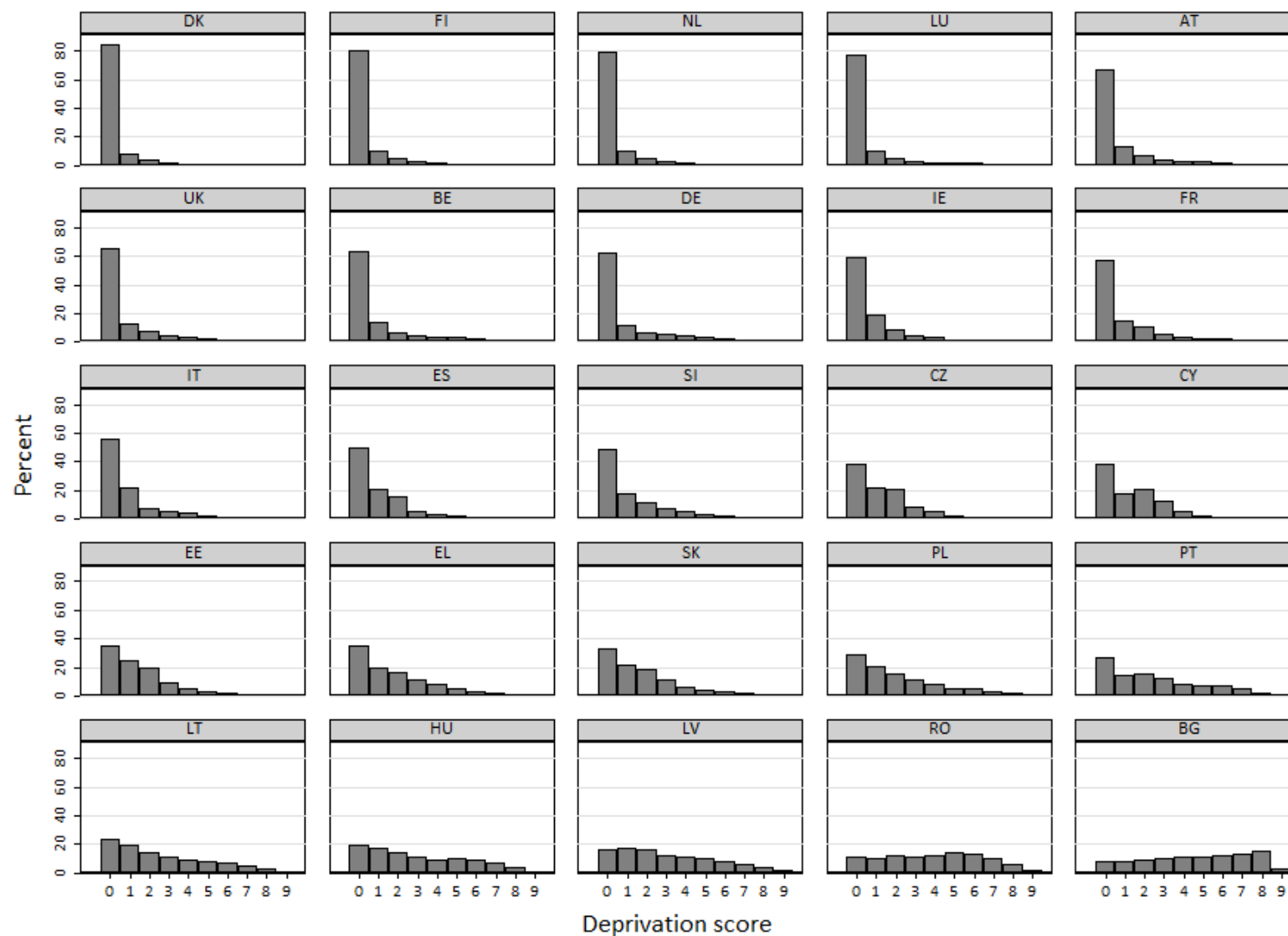
How do we distinguish deprived from non-deprived, high from low deprivation? How is our understanding of material deprivation affected by these choices? The concept of material deprivation has gained prominence in the literature on poverty and disadvantage owing to the recognized problems of a sole focus on income. Material deprivation is generally defined as the enforced lack of food, clothing, heating, durables and social activities. These goods and services are assumed to be key conditions of life for social participation (Guio et al. 2016), or can be considered as the necessities for performing expected social roles (Townsend, 1979). Multiple counting indices are proposed for material deprivation (*or deprivation hereafter*) consisting of an *a priori* selected binary items (*inter alia* Whelan & Maître, 2012; Guio et al., 2016). Deprivation items are self-reported enforced lack of goods, deprivation score is the total number of deprived items, and the deprived (vs. non-deprived) is defined based on an arbitrarily assigned threshold on the deprivation score (e.g. having three or more deprived items).<sup>38</sup>

A recent literature analyzes the determinants of deprivation using these counting indices. Some scholars focus on exploring the differences in the risk of being deprived (deprived vs. non-deprived), while others focus on explaining the variation in deprivation level (low vs. high deprivation). Despite providing substantial evidence on explaining deprivation, these studies neglect a common and important feature of deprivation data. Figure 1 shows the distribution of deprivation for 25 EU countries using 9-item index of Whelan & Maître (2012). In all countries, there is a clustering at zero: a majority of the population in almost each country has no deprivation.

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<sup>38</sup> Enforced lack refers to the cause of deprivation being affordability problems.

**Figure 1: Distribution of deprivation in EU-25 - 9 item scale of Whelan and Maitre**



Notes: The histograms reflect the score of 9-item index by Whelan and Maitre (2012) See data and methodology section for details of the index. Sweden and Malta are excluded due to data problems. The graphs emphasize the excesses of zeros. The number raises around 80% for Denmark, Finland and Netherlands.

The excess of zeros has substantive implications for defining and analyzing deprivation.<sup>39</sup> Zero is a conceptually meaningful phenomenon, indicates a state of no deprivation, while even one indicates some level of deprivation. Moreover, the very high prevalence of zeros suggests a distinct data generating process: people with zero deprivation might have a distinct risk profile than people with at least one deprivation, and hence zero might be qualitatively different from counts (one, two ... nine).

If zeros are qualitatively distinct from counts, i) zero can be considered as a natural threshold for the analysis of deprivation risk (deprived vs. non-deprived), and ii) zeros must be excluded from the analysis of deprivation level (low vs. high deprivation). However, conventional models of deprivation risk employ an arbitrarily assigned threshold (usually two (3+)), and the conventional models of deprivation level include zeros into the analysis. Therefore, if zeros are distinct, the conceptual assumptions of conventional models do not hold, thus they might give unreliable estimates.

In this article, the aim is i) to test the distinctiveness of zero deprivation and ii) to examine its substantive consequences for understanding material deprivation. *To test the distinctiveness of zeros*, first, I visually compare the risk profiles of deprivation groups (zeros vs. counts) based on an exploratory data analysis; secondly, applying and comparing multiple count models, I formally test whether the models that account for zeros and counts separately fit the data better than the models that account for zeros and counts together.

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<sup>39</sup> There are also methodological implications of the excess of zeros as deprivation is usually examined based on OLS models, but given the excess of zeros and count nature of data, the main assumptions of constant variance, normality of residuals, and linearity of the relationship cannot be easily assumed (King, 1988).

*To examine the substantive consequences of a possible distinctiveness of zeros, I focus on two questions: i) are the risk and level of deprivation socially structured based on social class? ii) Do the processes that generate deprivation continue to affect the accumulation of deprivation; in other words, are the determinants of the risk and the level of deprivation same? The idea is to compare, based on the questions above, the results of conventional models to the results of a model that account for the distinct zeros. As I argue later, in the presence of distinct zeros, an appropriate modeling strategy for deprivation is using mixture count models, specifically hurdle models. Hurdle models account for two distinct data generating processes (selection into zeros and determination of the deprivation level), which allow for a flexible and appropriate modelling of both risk and level of deprivation. Using EU-SILC 2009, the analysis is run separately for 25 EU countries given their varying rates of zeros. Therefore, a last question to examine is whether the findings depend on the level of zeros in a country.*

## **2. Explaining material deprivation – existing literature, theory and hypotheses**

Risk and level perspectives are widely used in the European poverty literature. Deprivation risk is analyzed to show different risk profiles of income poverty and material deprivation (Whelan et al., 2004), to choose between alternative poverty measures (Whelan & Maitre, 2009) and to examine the impact of individual risk factors and certain institutional factors on the risk of deprivation (Dewilde, 2008; Nelson, 2012). Similarly, deprivation level is studied to question the validity of income poverty thresholds in identifying the most deprived households (Whelan et al., 2001), to explore individual level (Layte et al., 2001; Berthoud & Bryan, 2011) and macro level (Whelan & Maître, 2012; Bárcena-Martín et al., 2014) factors in explaining deprivation level.

Despite the important contributions these studies make, two issues are neglected in this literature. First, in explaining the risk of deprivation, the primary concern is typically on the labor market and demographic characteristics, placing greater emphasis on the individual responsibility of poverty; but whether the risk of deprivation is socially structured based on social class attracted rather limited attention (Goldthorpe, 2010). Secondly, deprivation risk and level are used to study similar problems without making a clear distinction between the two; but the two concepts represent different phenomena and whether the same factors determine both processes, and if so why (and if not why not), are important substantive questions.

A theoretical framework based on class and life course risks is helpful in explaining the risk and level of deprivation and forming hypotheses on these two issues (Vandecasteele, 2011). As defined above, deprivation depends on the household's command over resources vis-à-vis their needs. In various life course events such as partnership dissolution, single parenthood, and childbirth, households face higher needs and/or lower economic resources, and hence might experience spells of deprivation. According to this individualistic view, the nature of deprivation is predominantly temporary, persisting until the balance of needs and resources is restored.

A rather more structural view is rooted in class relations, situating material deprivation within the institutionalized social relations through which a highly unequal distribution of economic resources as well as needs are generated and sustained (Townsend, 1979: 409-412; Goldthorpe, 2010). The interest is on identifying the institutions that stratify society into discrete classes given their typical set of constraints and opportunities for life. One such theory defines the class positions based on employment relations, where two distinctions are key (Erikson & Goldthorpe, 1992). The first is among employers,

self-employed and employees given their relationship to the means of production. The second is among employees based on their type of contract, mainly between *service* and *labor* contracts, distinguished by the differences in human asset and difficulties in monitoring. These two forms of employment regulation might occur in degrees hence *mixed forms* also exist. The theory is operationalized based on an European Socio-Economic Classification (ESEC) scheme which is shown to be a valid measure for comparative use across the EU (Rose & Harrison, 2014). Education and gender are also usually considered as other social stratification determinants (Vandecasteele, 2011).

Other important factors such as current income, unemployment, house ownership and long-term ill-health are endogenous to class and life course variables. In other words, the effects of class and life course variables on deprivation are mediated through low and unstable income, unemployment, ill-health and tenancy (Borg & Kristensen, 2000; Goldthorpe & McKnight, 2006; Kurz & Blossfeld, 2004; Özcan & Breen, 2012; Pintelon et al., 2013). Yet an important question is whether the class and life course risk effects are partly or totally mediated by these intervening variables; and whether these processes differ for deprivation risk and deprivation level.

Deprivation risk shows differences between the deprived and the non-deprived, while deprivation level reflects the differences between those with low and high deprivation. If zero is conceptually distinct to counts, then deprivation risk shows the differences between zeros and counts, while deprivation level shows the differences among counts. Therefore, while deprivation risk examines variance in the whole population, deprivation level focuses on variance among those with at least one deprivation. Based on their study on Ireland, Whelan et al. (2007) argue that the social class and education gradients on multiple deprivation are lower than expected because i) class variables are

more powerful discriminating across a general population and ii) once we focus on the most disadvantaged, the effect of class variables are mediated through rather than accumulated on the effect of other factors (see Vandecasteele, 2011 for similar findings for 13 EU countries).

In this context, hypotheses for the two alleged questions are as followed: regarding the first question on social class gradient, we expect a systematic variation in deprivation risk by social class, especially among service, mixed and labor classes; and for deprivation level, the class gradient is expected to be not as strong as in deprivation risk, mainly because the analysis is already focused on the more disadvantaged classes. Regarding the second question on comparing risk and level perspectives, we expect a net effect of all relevant factors on the deprivation risk, but for the deprivation level, most of the class and life course effects are expected to be mediated, hence the net effects might either disappear or diminish.

Two further issues are of relevance to these hypotheses. First, the analyses focus on exploring common regularities across EU countries although a certain level of country variance is expected in relation to the level of zeros. Still, the expected process and differences between conventional and hurdle models should be more or less consistent across countries.

Secondly, the hypotheses are not expected to apply to conventional models that do not account for the distinctiveness of zeros. Conventional models on deprivation risk typically apply *ad hoc* non-zero thresholds. If zeros are qualitatively distinct as hypothesized, these conventional models underestimate the effects of explanatory factors on the risk of deprivation. This is mainly because i) the average differences in explanatory factors are expected to be largest between zeros and others and ii) in the

case of a non-zero threshold (e.g. 3+), non-deprived group includes, in addition to zero, some other count groups (e.g. ones and twos) which dilute the average differences between deprived and non-deprived groups. Also, conventional models of deprivation level include zero in the analysis with the assumption that zero is determined by the same process as of counts. If zeros are qualitatively distinct as hypothesized, these conventional models overestimate the effects on the level of deprivation. This is mainly because i) the average differences in explanatory factors are expected to be largest between zeros and others, and ii) when zeros are included into the analysis, the estimates are superfluously raised by the differences between zeros and counts while the main interest is explaining the differences among counts.

### **3. Data and methodology**

#### *3.1. Case selection*

The study aims to generalize over the EU. The analysis is run separately for each country, but for clarity in presentation, the analysis of the consequences of distinct zeros is presented for four countries in the main text, namely Denmark, France, Portugal and Hungary. The results for other countries are presented in Supplementary Material, and references are made in the main text where relevant. These four countries are selected based on their level of zeros, each representing a group with similar level of zeros – Denmark from high, France from medium-high, Portugal from medium-low, and Hungary from low group (see Table 1). The four groups show quartiles of the distribution of level of zeros across countries. By comparing the results of these four countries, I investigate the impact of the rate of zero in the country on the consequences of neglecting distinct zeros.

**Table 1: Country classification based on rate of zeros**

High (1 <sup>st</sup> quartile)	Medium-high (2 <sup>nd</sup> quartile)	Medium-low (3 <sup>rd</sup> quartile)	Low (4 <sup>th</sup> quartile)
<b>DK 84.1</b>	AT 66.8 <b>FR 57.6</b>	CZ 38.6 PL 28.5	LT 23.4
FI 80.1	UK 65.4 IT 55.7	CY 38.4 <b>PT 26.3</b>	<b>HU 18.9</b>
NL 78.9	BE 63.4 ES 49.3	EE 34.9	LV 16.2
LU 76.9	DE 62.9 SI 49.1	EL 34.5	RO 10.7
	IE 59.6	SK 32.6	BG 7.6

Notes: The numbers represent the rate of zeros in the country. Bold are the selected countries.

### 3.2. Data

EU-SILC 2009 is used for the analysis which includes a special module on material deprivation. The unit of analysis is the household reference person (HRP). There are two reasons for this choice: i) most of the deprivation information is collected at the household level which, in an individual level analysis, might cause clustering at the household level; ii) information on some deprivation items (e.g. clothes, shoes, and social activities) and health indicators is collected only for the HRP in countries such as Denmark, Finland and Netherlands.

### 3.3. Empirical model

The main analysis is based on the 9-item index of Whelan & Maître (2012) (*WM hereafter*). The index score is calculated as a raw sum of nine binary deprivation items described in Appendix. Following the common practice, threshold for deprivation is selected as being deprived on three or more items. Presented in Supplementary Material, the main analysis is repeated for two other deprivation indices (e.g. weighted WM and 13-item index of Guio et al. (2016)) to test sensitivity to weighting and index specification.

Informed by the theoretical framework, the following explanatory variables are used. *Social class* is constructed based on the European Socio-Economic Classification (ESEC) using the two-digit ISCO codes. Originally 10 class schema, given the problems of constructing the schema with two-digit codes, ESEC 5 class version with an inclusion of the “excluded (never worked)” category is employed.<sup>40</sup> The five classes are named based primarily on their employment relations as the gradient is expected to be between salariat, mixed and labor classes. Income variable is the household disposable income, equivalized using OECD scale and used in a log form in the regressions. The education variable is three category version of ISCED, reflecting the highest educational level attained.<sup>41</sup> Other variables such as gender, unemployment, being single parent, having three children, disability and chronic health problems in the household and being a tenant are constructed as binary variables. Also, age is included as a control variable.<sup>42</sup> See Appendix (Table A1) for descriptive statistics for all variables.

### 3.4. *Missing data*

Missing data for the main variables of interest are presented for the whole sample and separately for each country in Appendix (Table A1-A2). Sweden is excluded due to significant missing cases (around 30%) on the deprivation index, and so as Malta due to coding problems in social class variable. For the whole sample, the missing rate for the deprivation index is 2%, for other variables lower than 1% and in total around 4%. For the UK, around 8% has missing data on the deprivation index, but social class and income distributions of the missing and non-missing samples are very similar. For the

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<sup>40</sup> The categories are “service”, “mixed”, “small self-employed”, “labor non-manual”, “labor manual” and “excluded”.

<sup>41</sup> The categories are tertiary, higher secondary, and lower secondary and below. For the exploratory analysis, six category ISCED is used.

<sup>42</sup> Categories are 15-30, 31-45, 46-65, 65-79 and 80+.

Netherlands, Denmark and France, around 3-4% has missing information on social class but a similar distribution of deprivation with the non-missing sample. Therefore, the analysis is held based on non-missing cases.

### 3.5. Count models

Count models are extensively used for analyzing count outcomes for example in studies of fertility behavior (e.g. number of children) (Parrado & Morgan, 2008), labor market outcomes (e.g. unemployment spells, number of job changes) (Andress, 1989), and health care utilization (e.g. number of doctor visits) (Deb & Trivedi, 1997). The most basic count model, Poisson model (PM), assumes equal conditional variance and mean:

$$\mu_i = E(y_i | x_i) = \exp(x_i \beta) = \lambda_i$$

$$Var(y_i | x_i) = \lambda_i$$

Yet, usually the data is over-dispersed: conditional variance exceeds conditional mean. Three reasons for over-dispersion are unobserved heterogeneity, dependence of observations, and the existence of more than one data generating processes (Cameron & Trivedi, 2013). More advanced models such as negative binomial (NBM) includes unobserved heterogeneity with an additional parameter( $\delta_i$ ):

$$\mu_i = E(y_i | x_i, \varepsilon_i) = \exp(x_i \beta + \varepsilon_i) = \exp(x_i \beta) \delta_i$$

The distribution of  $\delta$  is gamma with one parameter  $v$ ; then  $E(\delta_i) = 1$ ,  $Var(\delta_i) = \frac{1}{v} = \alpha^{-1}$ , where  $\alpha$  is the dispersion parameter. In both of these models, zeros are still modeled together with the counts assuming that they are determined by the same data generating process.

Hurdle models assume a two-stage process: i) the probability of zero is usually modeled with a binary logistic model, and ii) for the ones crossed the “hurdle” of zero, the level of deprivation is modeled by a zero-truncated Poisson or zero-truncated negative binomial model. The binary and count parts can be assumed as two separate components allowing the process determining zeros to be distinct from the process generating counts (Cameron & Trivedi, 2013). Therefore, if the zeros are distinct, we expect a better fit for the hurdle compared to standard Poisson and negative binomial models. The preference between HPM and HNBM depends on whether further unobserved heterogeneity exists in the model.<sup>43</sup>

### 3.6. *Analytical strategy*

To test the distinctiveness of zeros, primarily, risk factors (Y) are plotted against the deprivation score (X) which can help detect the distinctiveness of zero group visually. Secondly, multiple count models are compared in terms of their model fit. A better model fit in hurdle vis-à-vis standard Poisson or negative binomial model is an indication of a distinct data-generating process for zeros.

Three statistical tests are used to select between models (Cameron & Trivedi, 2013; Long & Freese, 2014). The first is the likelihood ratio test of the dispersion parameter  $\alpha$ . The null hypothesis is  $\alpha = 0$ , in which case negative binomial model equates to Poisson model. Therefore a significant test value shows overdispersion and a preference for negative binomial over Poisson model. The second is the Vuong test, a maximum likelihood test for non-nested models used to choose between hurdle and standard

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<sup>43</sup> Other similar mixture count models such as zero-inflated models are not appropriate for deprivation data as they assume some structural zeros (individuals with a zero probability of deprivation) which is theoretically not possible given that any individual might experience deprivation when they face extreme risk conditions.

count models. The Vuong statistic  $\frac{LL(HNBM)-LL(NBM \text{ or } PM)}{sd/\sqrt{n}}$  where LL is assumed to have a standard normal distribution, so a value higher than 1.96 shows a preference for hurdle model, while lower than -1.96 shows a preference for standard count model (Poisson or negative binomial). AIC and BIC corrected versions of the Vuong test proposed by Desmarais & Harden (2013) which account for the differences in the number of parameters are also used in the analysis. The third is the likelihood ratio test to choose between HPM and HNBM. In addition, information criteria (AIC and BIC) are also examined between the models (Kuha, 2004).

To answer the two substantive questions, the conventional models of risk and level are compared to the best-fit count model based on significance and effect size. For comparability between models, average marginal effects (AMEs) are used.<sup>44</sup> To examine the differences across countries, the models are run separately for each country.

#### **4. Are zeros distinct?**

To test the distinctiveness of zeros, firstly, the risk profiles of each deprivation group is explored visually for important explanatory variables. Secondly, count models are compared to formally test the hypothesis of distinct zeros.

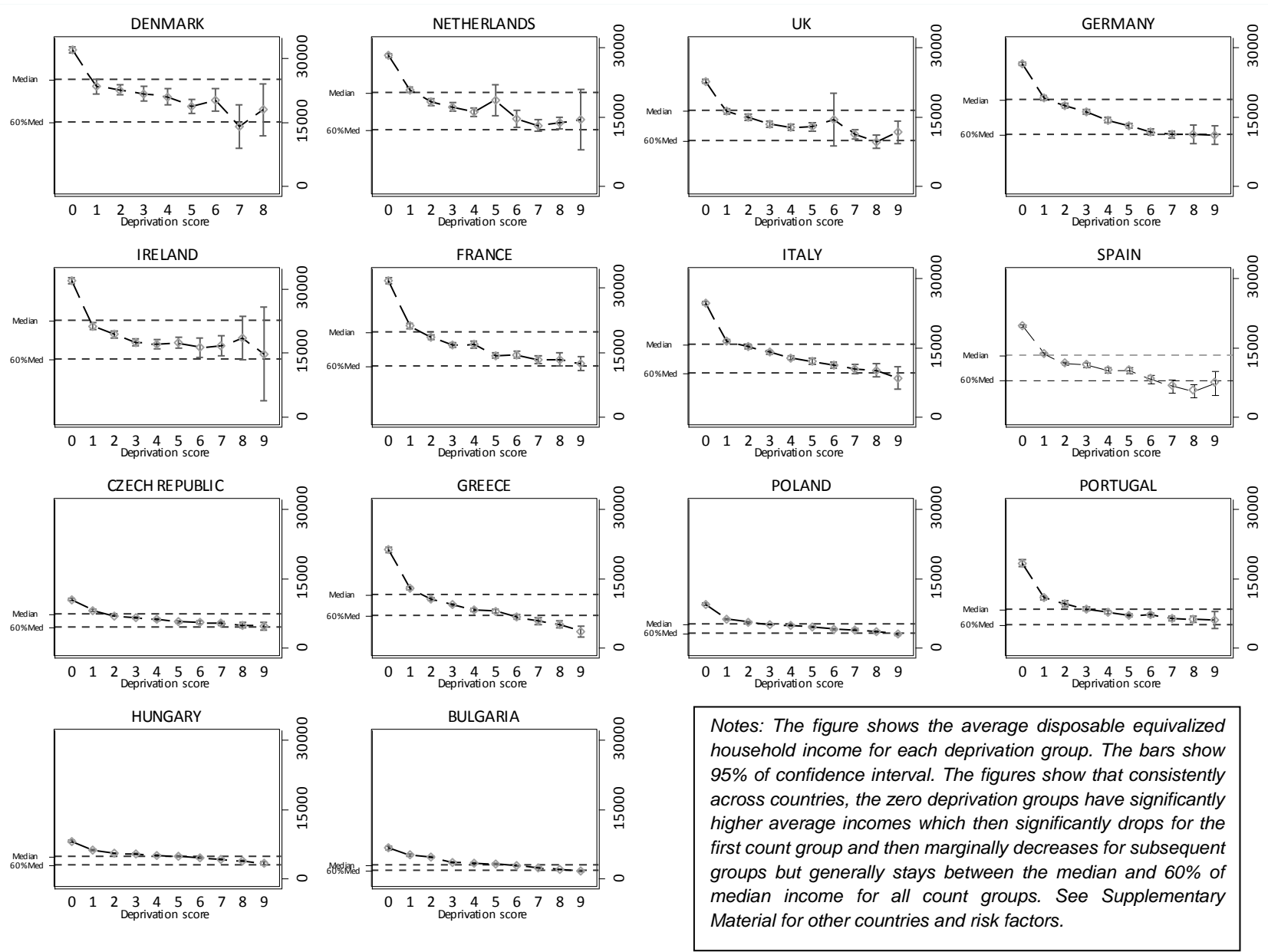
##### *4.1. Exploratory data analysis: risk profiles of deprivation groups*

Figure 2 shows the average equivalized household disposable income for each deprivation group and for 14 countries selected from each country group (see Supplementary Material for other countries). The graphs reveal an important curve linear

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<sup>44</sup> AMEs are preferred since log-odds and odds ratio includes some unobserved heterogeneity which might vary across the applied models given their variant specifications (Mood, 2010). The marginal effects for the count part are estimated for the whole sample of the reference country.

**Figure 2: Average income levels for each deprivation group across 14 EU countries**



trend consistent across countries. The average income of the zero group is significantly above the median income, which drops below median in the first count, and for the subsequent counts, slightly decreases but stays above 60% of median income (this pattern is more apparent in high and medium-high than in medium-low and low country groups). More importantly, this curve linear trend, where the slope is the highest for the first count, is observed not only for income but also for social class, education and ill health (except Bulgaria which shows rather a linear trend - see Supplementary Material).

These results have three important implications. First, due to the significant fall (or jump for negative risk factors) at the first count, the risk profile of zero deprivation group is separated and significantly different from other count groups. For example, in Ireland, average household income of the zeros is above 30.000 euros, while it is between around 15000 and 20000 euros for all other groups. Secondly, despite a decreasing (or increasing) trend over higher deprivation groups, the risk profiles of the count groups are very similar to each other. For example, the group average incomes are generally between the country median income and the country relative income poverty line (60% of median). Thirdly, given the curve linear bivariate relationships between deprivation and risk factors, the bulk of the variation comes from the differences between zeros and counts, and not from the differences among counts. This shows that identified risk factors are mostly useful in explaining the risk than the level of deprivation.

#### *4.2. Comparing count models*

If zeros are distinct, zeros should be modelled separately and hence hurdle models should fit the data better than standard count models. To formally examine this, Poisson model (PM), negative binomial model (NBM) and hurdle Poisson (HPM) and hurdle negative binomial model (HNBM) are compared using multiple statistical tests.

As shown in Table 2, for all 25 EU countries, i) the dispersion parameters ( $\alpha$ ) are significantly higher than zero and the likelihood ratio tests are significant, indicating a preference for the NBM over PM (except Bulgaria); ii) Vuong statistics are positive and bigger than 1.96, showing a preference for hurdle model<sup>45</sup>, and iii) likelihood ratio test between HNBM and HPM shows a significant result showing a preference over HNBM model (except Cyprus, Romania and Bulgaria). AIC, BIC values also suggest a similar result (see Appendix Table A3): for all countries the lowest AIC and BIC values are for the HNBM (or HPM for Cyprus, Romania and Bulgaria).

These results give strong supporting evidence to the hypothesis that zeros are generated by a distinct process than counts, thus zero deprivation represents a qualitatively distinct phenomenon. As described in Supplementary Material, these analyses are also repeated for a prevalence-weighted WM index and 13-item index of Guio et al. (2016) with the same results. Therefore, the findings are robust to different prevalence weighting and index specification.

## **5. Consequences of neglecting distinct zeros on our understanding of material deprivation**

If zeros are distinct, the threshold of deprivation can be set at zero, and zeros should be excluded from the models of deprivation level. However, conventional models of deprivation risk use a threshold of two, and the conventional models on deprivation level includes zeros in the analysis. In this section, I show how the results on the relationship between social class and deprivation, and on the determinants of the risk and level of deprivation are distorted due to not accounting for the distinctiveness of zeros.

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<sup>45</sup> For the BIC-corrected Vuong, Denmark and Estonia are exceptions, where the test cannot distinguish between NBM and HNBM.

**Table 2: Model selection between PM, NBM, HPM and HNBM – tests**

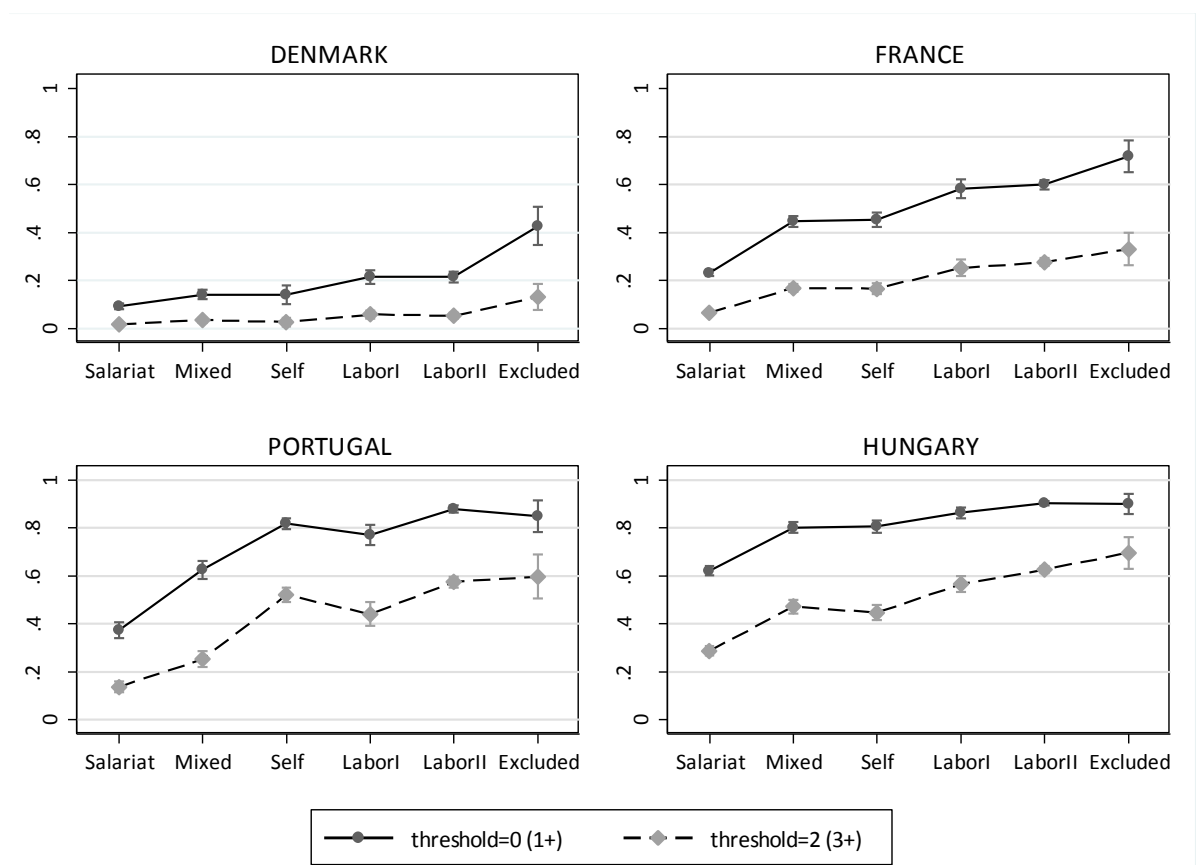
Country	% of zeros	PM vs. NBM		NBM vs. HNBM			HNBM v. HPM
		Alpha ( $\alpha$ )	LR test of $\alpha = 0$	Vuong	Vuong AIC-cor	Vuong BIC-cor	LR test
DENMARK	84.1	2.93	981 (pr>0.00)	5.7	4.3	-0.5	83 (pr<0.00)
FINLAND	80.1	1.89	1433 (pr>0.00)	8.3	7.4	4	105 (pr<0.00)
NETHERLANDS	78.9	1.77	1447 (pr>0.00)	8.7	7.8	4.5	73 (pr<0.00)
LUXEMBOURG	76.9	1.43	847 (pr>0.00)	7.9	6.8	3.5	96 (pr<0.00)
AUSTRIA	66.8	1.39	1890 (pr>0.00)	9.4	8.5	5.4	159 (pr<0.00)
UK	65.4	1.34	2188 (pr>0.00)	12.6	11.9	9.6	157 (pr<0.00)
BELGIUM	63.4	1.17	1990 (pr>0.00)	10.5	9.7	7	249 (pr<0.00)
GERMANY	62.9	1.30	4718 (pr>0.00)	19.7	19.2	17.6	199 (pr<0.00)
IRELAND	59.6	0.72	734 (pr>0.00)	8.8	7.8	4.5	177 (pr<0.00)
FRANCE	57.6	0.84	2384 (pr>0.00)	14.4	13.8	11.4	282 (pr<0.00)
ITALY	55.7	0.93	5082 (pr>0.00)	14.5	13.9	11.6	1426(pr<0.00)
SPAIN	49.3	0.51	1494 (pr>0.00)	12.5	11.8	9.1	289 (pr<0.00)
SLOVENIA	49.1	0.69	1843 (pr>0.00)	11.9	10.9	7.7	205 (pr<0.00)
CZECH REPUBLIC	38.6	0.24	495 (pr>0.00)	11.2	10.2	6.6	68 (pr<0.00)
CYPRUS	38.4	0.16	74 (pr>0.00)	8.7	7.5	3.9	0 (pr<0.99)
ESTONIA	34.9	0.24	288 (pr>0.00)	7.9	6.4	1.6	51 (pr<0.00)
GREECE	34.5	0.18	423 (pr>0.00)	12.7	11.9	9.5	37 (pr<0.00)
SLOVAKIA	32.6	0.27	405 (pr>0.00)	10	8.9	5.1	75 (pr<0.00)
POLAND	28.5	0.29	1685 (pr>0.00)	15.3	14.6	11.9	607 (pr<0.00)
PORTUGAL	26.3	0.24	534 (pr>0.00)	11.9	11.1	8.6	80 (pr<0.00)
LITHUANIA	23.4	0.32	868 (pr>0.00)	7.6	6.3	1.9	218 (pr<0.00)
HUNGARY	18.9	0.21	1004 (pr>0.00)	15	14.3	11.9	152 (pr<0.00)
LATVIA	16.2	0.16	408 (pr>0.00)	7.6	6.4	2.4	94 (pr<0.00)
ROMANIA	10.7	0.06	122 (pr>0.00)	14.1	13.6	11.5	0 (pr<0.99)
BULGARIA	7.6	0.002	0.25 (pr>0.31)	11	10.3	7.9	0 (pr=0.99)

*Notes: The table presents results of fit statistics for 25 EU countries, comparing multiple count models. Alpha is a dispersion parameter. Any value bigger than zero reflect over-dispersion and preference over negative binomial model (NBM). Vuong test (as well as its bias corrected versions) is a maximum likelihood test for non-nested models used to choose between hurdle vs. standard models. The null hypothesis is equal fit hence numbers higher than 1.96 shows a preference for hurdle models. In the table, the countries are ordered from highest to lowest level of zeros. There is significant over-dispersion for all countries associated to the level of zeros. Hurdle models (HNBM or HPM) are the preferred model for all countries.*

### 5.1. Social class variation on the risk and the level of deprivation

Figure 3 shows bivariate relationship between social class and deprivation risk across four countries. The y-axis shows the average predicted risk of deprivation. The solid lines show the estimates from hurdle models where the threshold for deprivation is zero (1+); the dashed lines show the estimates from conventional logit models where the threshold for deprivation is two (3+).

**Figure 3: Social class variation on deprivation risk using different thresholds**



Notes: The figure shows the average predicted risk of deprivation for social classes across four countries. The models do not include any control variables. The solid lines show the estimates from models where the threshold for deprivation is two (3+), the dashed lines show the estimates from models where the threshold for deprivation is zero (1+). The figure demonstrates that social gradient in deprivation risk is much clearer when the threshold is zero except for Hungary, where the gradient is stronger for threshold two partly due to a ceiling effect for the threshold of zero.

A strong social class gradient in the risk of deprivation can be observed for all countries when the threshold is zero. Mixed class has in average significantly higher risk of deprivation than salariat; non-manual and manual labor have in average higher risk of deprivation than both mixed and salariat. Yet, when the threshold is two, these gradients disappear in Denmark, diminish in France and Portugal. Only in Hungary, the gradient is stronger when the threshold is two than it is zero.

As shown in Supplementary Material, similar patterns are observed for other countries. For the countries with high and medium level of zeros, differences in deprivation risk among salariat, mixed and labor are much clearer when the threshold for deprivation is zero than two.<sup>46</sup> Therefore, for these countries, using a higher threshold masks the strong social class gradient in the risk of deprivation. On the other hand, for countries with low level of zeros, the social class gradient is more apparent when the threshold is two than it is zero (mainly due to a ceiling effect).<sup>47</sup> Therefore, for these countries, using a zero threshold might obscure the actual social class gradient in the risk of deprivation.

Figure 4 shows the bivariate relationship between social class and deprivation level across four countries. The y-axis shows the average predicted level of deprivation. The solid lines show the estimates from the count part of the hurdle model which does not include zeros into the analysis; the dashed lines show the estimates from conventional OLS models which include zeros into the analysis.

As hypothesized, the social gradient in the level of deprivation is not strong in the hurdle models without zeros. However, when zeros are included into the analysis, a higher

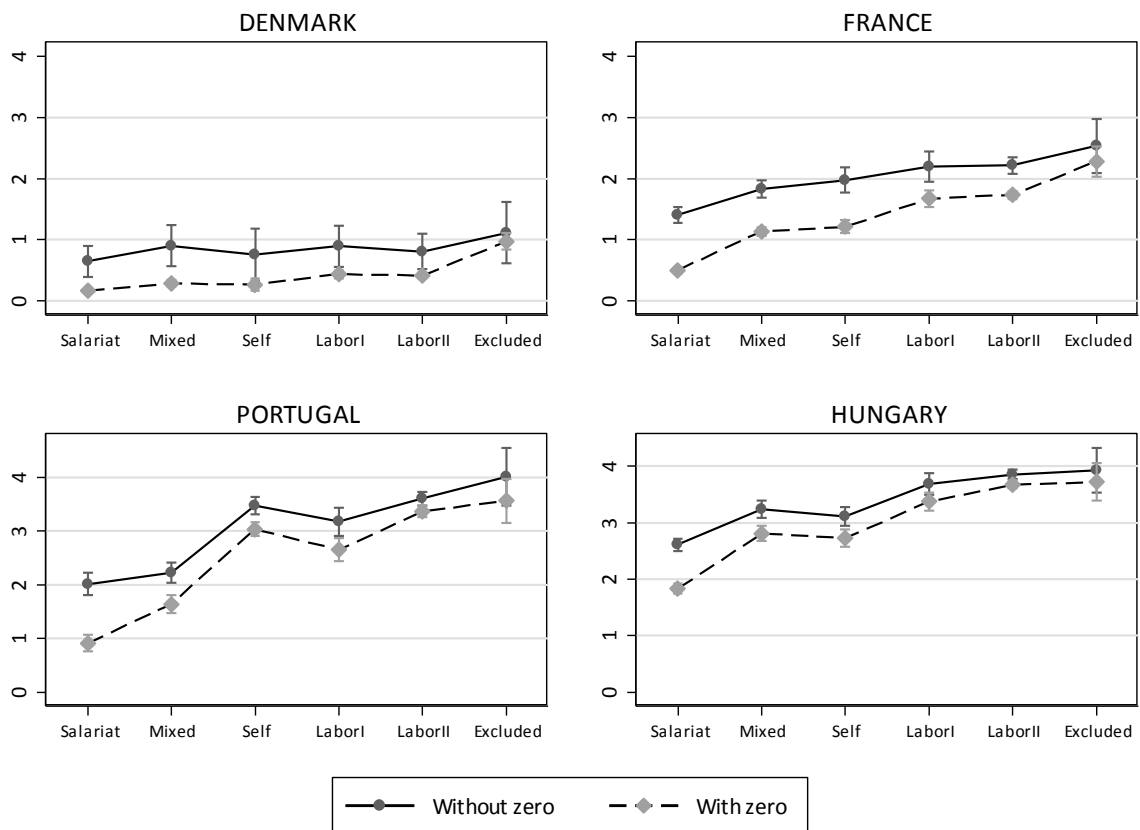
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<sup>46</sup> For some countries in medium-low group, such as Czech Republic, the gradient is not different in two thresholds.

<sup>47</sup> Due to very high prevalence of deprivation in countries with low level of zeros, the risk of deprivation for all classes except salariat are very close to 1, which limits the possibility of a gradient between lower classes.

variation across classes exists. In the OLS with zeros compared to the hurdle model without zeros, the excluded has in average significantly higher level of deprivation than the salariat in Denmark; the gradient between all classes is more apparent in France; and, the distance between salariat and other classes is wider in Portugal and Hungary. As shown in Supplementary Material, the results are similar for all other countries.<sup>48</sup> Therefore, including zeros into the level analysis causes some spurious social class effect on the level of deprivation.

**Figure 4: Social class variation on deprivation level - with and without zeros**



Notes: The figure shows the average predicted level of deprivation for social classes. The models do not include any control variables. The solid lines show the estimates from zero-truncated negative binomial models which do not include zeros into the analysis; the dashed lines show the estimates from OLS models which include zeros into the analysis. The figure demonstrates that social gradient in deprivation level is inflated when the zero is included into the analysis.

<sup>48</sup> Two exceptions are Italy and Bulgaria, where the two models give similar results.

## 5.2. *Determinants of risk vs. level of deprivation*

Table 3 shows the results of hurdle and conventional hurdle models on the risk and the level of deprivation. Between the risk and level models, only the significance of explanatory factors is of interest. Effect sizes are not comparable as the risk models show effects on the probability of deprivation, while the level models show effects on the level of deprivation.

Based on the hurdle models, the determinants of the risk and the level of deprivation appear to be substantially different in Denmark, France and Portugal. As hypothesized, most of the class and life course factors significantly explain the risk of deprivation, while only some significantly explain the level of deprivation. For example, in Denmark most factors significantly increase deprivation risk, while only income, house ownership and single parenthood significantly increase deprivation level. In Portugal, lower education and single parenthood significantly increases the risk but not the level of deprivation. Thus, the differences between the risk and level models are clearer in Denmark than in Portugal. Only in Hungary, the determinants of risk and level of deprivation are similar.

As shown in Supplementary Material, this pattern also seems to be similar for other countries. In countries with high and medium level of zeros, as hypothesized, there are net effects of class and life course factors on the risk of deprivation, while for deprivation level, most of the class and life course effects are mediated through income, unemployment, health and/or house ownership.<sup>49</sup> Only in countries with low level of zeros, same factors explain both the risk and the level of deprivation.

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<sup>49</sup> The differences are clearer for countries with high level of zeros (e.g. Finland) than countries with medium level of zeros (e.g. UK and Greece). One clear exception is Germany where class and life course factors significantly explain both the risk and the level of deprivation.

**Table 3: Determinants of risk and level – hurdle vs conventional models**

	DENMARK				FRANCE				PORTUGAL				HUNGARY			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional		Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk	Level	Risk	Level	Risk	Level	Risk	Level	Risk	Level	Risk	Level	Risk	Level	Risk	Level
<b>Stratification var.</b>																
HRP Social Class (ESEC 5)																
Mixed	0.02	0.16	0.01	0.04	0.05**	0.08	0.02*	0.06	0.09***	0.18	0.07**	0.22*	0.02	0.26**	0.05**	0.23**
Small self-emp.	0.03	0.00	0.01	0.06	0.04*	0.23*	0.01	0.19**	0.09***	0.83***	0.16***	0.73***	-0.02	-0.18	-0.03	-0.22*
Labor non-manual	0.04**	0.07	0.02*	0.07	0.06**	-0.01	0.01	0.15*	0.10***	0.65***	0.13***	0.57***	0.04**	0.33**	0.07***	0.37***
Labor manual	0.08**	0.02	0.02**	0.11**	0.09**	0.17*	0.05**	0.30**	0.17***	1.08***	0.23***	1.13***	0.07***	0.41***	0.11***	0.54***
Excluded	0.13**	0.15	0.04**	0.50**	0.07	0.01	-0.01	0.39**	0.10*	0.92***	0.18***	0.88***	-0.01	0.17	0.10**	0.11
HRP Education																
Upper secondary	0.00	0.03	0.01	-0.00	0.07**	0.13	0.04**	0.09*	0.06	-0.45	-0.00	-0.14	0.06***	0.44***	0.10***	0.44***
Lower secondary ≥	0.00	0.12	0.01	0.05	0.11**	0.28**	0.08**	0.37**	0.11***	-0.15	0.06	0.12	0.11***	0.67***	0.15***	0.79***
HRP Female	0.04**	-0.04	0.01	0.06*	0.08**	0.48**	0.07**	0.41**	0.05***	0.55***	0.08***	0.59***	0.06***	0.28***	0.06***	0.38***
<b>Life course var.</b>																
HRP Divorced	0.07**	0.10	0.02*	0.19**	0.08**	0.33**	0.07**	0.42**	0.04	0.18	0.04	0.23*	0.02*	0.28***	0.06***	0.33***
HRP Single parent	0.14**	0.39*	0.06**	0.59**	0.04*	0.18*	0.04**	0.42**	0.07*	0.19	0.09*	0.35	0.02	0.21	0.07**	0.32**
HH 3+ children	0.04	0.16	0.01	0.11	0.05*	0.21	0.05**	0.27**	0.05	0.71*	0.14**	0.82***	0.03	0.58***	0.10***	0.66***
<b>Mediating var.</b>																
HH Income (log equ.)	-0.10**	-0.30**	-0.02**	-0.23**	-0.32**	-0.85**	-0.18**	-0.92**	-0.22***	-1.00***	-0.25***	-1.29***	-0.24***	-1.38***	-0.30***	-1.76***
HRP Unemployed	0.19**	0.27	0.07**	0.71**	0.22**	0.62**	0.15**	1.34**	0.10***	0.51***	0.11***	0.68***	0.08***	0.50***	0.14***	0.82***
HH Chronic ill-health	0.03**	0.19	0.01*	0.10**	0.04**	0.09	0.02*	0.14**	0.05***	0.34***	0.09***	0.39***	0.04***	0.09	0.03*	0.21***
HH Disability	0.06**	0.13	0.02**	0.18**	0.08**	0.43**	0.07**	0.39**	0.05***	0.37***	0.06***	0.44***	0.06***	0.48***	0.10***	0.55***
HH Tenant	0.09**	0.27**	0.04**	0.28**	0.11**	0.54**	0.09**	0.62**	0.09***	0.47***	0.11***	0.66***	0.03*	0.73***	0.13***	0.73***

Notes: \* $p < 0.05$  \*\* $p < 0.01$ . The table compares the determinants of the risk and the level of deprivation for four countries (see Supplementary Material for all countries). The model also includes age as a control. The reference category for social class is salariat and for education is tertiary level. The risk of deprivation for the conventional models is estimated based on a threshold of two (3+) using logit. The level of deprivation for the conventional models is estimated using OLS. The coefficients show average marginal effects which is the average change in the probability of being deprived for the risk model and average change in the number of deprivations for the level model in relation to a discrete or marginal change in the variable while all others are held at their observed values. The results show that i) the determinants of the risk and the level of deprivation are different under the hurdle but similar under the conventional logit and OLS models (except Hungary), ii) the conventional model of deprivation level overestimate the effects, and iii) the conventional model of deprivation risk underestimate the effects (except Hungary).

We see, however, a different picture when the distinctiveness of zeros is neglected. Based on conventional models, the determinants of the risk and the level of deprivation are broadly similar. Consistently across countries, most of the class and life course factors explain both the risk and the level of deprivation. Therefore, in most cases, the net effects of both types of variables exist for both deprivation risk and deprivation level. As shown in Supplementary Material, the results are also similar for other countries without exception. Therefore, despite some variation across countries, in general, the determinants of the risk and the level of deprivation seems to be common under conventional models.

Two main reasons lie behind these differences between the hurdle and conventional models. First, in countries with high and medium level of zeros, the conventional models of deprivation risk underestimate the effects due to applying a higher non-zero threshold.<sup>50</sup> For example, the effect sizes of income in the hurdle models are two to three times that of the corresponding effect of income in the conventional models. As a result, many factors which significantly explain the risk of deprivation in the hurdle models do not significantly explain the risk of deprivation in the conventional models. Secondly, the conventional models of deprivation level overestimate the effects due to including zeros in the analysis. For example, the effect size of unemployment is at least %25 higher in the conventional than in hurdle models. As a result, many factors which significantly explain the level of deprivation in the conventional models do not significantly explain the level of deprivation in the hurdle models.

The main reason why conventional models of risk and level reveal common determinants can be that both risk and level models partly reflect the differences

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<sup>50</sup> Portugal and Poland are exceptions. Also, in countries with low level of zeros, hurdle models of deprivation risk underestimate the effects due to the previously mentioned ceiling effect.

between zeros and counts. Especially when the majority of cases in the sample are zeros, the differences between zeros and counts describe the bulk of variance and dominate the results for both risk and level. Relatedly, in countries with low level of zeros, we see the difference between conventional and hurdle models being partial. In other words, when the number of zeros is low, the consequences of ignoring their distinct nature are also limited.

## **6. Conclusion and implications for the measurement of deprivation and poverty in the EU**

The study hypothesized and tested the distinctiveness of zero deprivation, and examined its consequences for understanding deprivation risk and level for 25 EU countries. The exploratory data analysis and comparison of count models have confirmed that, consistently across all 25 countries, zeros are qualitatively distinct; in other words, zeros and counts are determined by a distinct data generating process; or, those who have zero deprivation has significantly different profiles to those who have at least one deprivation from a specified list of deprivation items. These results are also robust to different weighting and index specifications. Assuming the deprived can be distinguished from non-deprived based on the identified risk factors, the analysis therefore suggests that zero (1+) can be used as a conceptually and empirically valid threshold for deprivation.

The consequences of neglecting the distinctiveness of zeros are substantial for our understanding of the risk and the level of deprivation. The study focused on two substantive questions: i) whether the risk and the level of deprivation is socially structured; and ii) whether the determinants of the risk and the level of deprivation are

common. For both questions, the findings are contrary to theoretical expectations when the distinctiveness of zeros is neglected.

Regarding the first question, there is a clear social class gradient in the risk of deprivation when zero is taken as a threshold; yet conventional models show a much narrower gradient as they underestimate the effect as a result of using a higher threshold. For the level of deprivation, when zeros are excluded from the analysis as in hurdle models, there is expectedly a rather limited class gradient in the level of deprivation (mainly between salariat and labor classes); on the other hand, conventional models show a much greater gradient as they overestimate the effect as a result of including zeros into the analysis.

Regarding the second question, again, the hurdle model results fit to our theoretical expectations: after controlling for variables such as income, unemployment, health and house ownership, the net effects of class and life course risks persist for the risk of deprivation while they disappear for the level of deprivation. Yet the conventional models identify the same determinants for both the risk and the level of deprivation mainly because both risk and level models partly reflect the differences between zeros and counts.

These findings apply to all countries but those with very low level of zeros. The evidence is much stronger for countries with high level of zeros (e.g. Denmark) than in countries with medium-low level of zeros (e.g. Portugal); in other words, the higher the level of zeros, the worse the consequences of neglecting distinct zeros.<sup>51</sup> For the countries with

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<sup>51</sup> This also shows that the empirical difference between hurdle and OLS models is mainly due to how zeros are accounted in the model and not due to the differences in functional form. Indeed, when level of deprivation is estimated using OLS without including zeros, the results are very similar to those of hurdle model.

very low level of zeros, using a zero threshold for deprivation masks the actual social class gradient in the risk of deprivation; also, using hurdle models, more factors explain deprivation level rather than deprivation risk. This is mainly due to a ceiling effect, as in these countries, a zero threshold identifies a significant majority of the population as deprived which limits the variance to be explained.

These findings partly reflect the wide inequality among EU countries, but also issues related to the reliability of deprivation data. For example, in countries with low level of zeros, deprivation rate for some items (e.g. holiday, furniture) are above 70%. Such high rates raise suspicion about the reliability of these items as deprivation indicators in less affluent countries, where the problems might be related to cross-cultural inequivalence, as these items might not have the same meaning in all EU countries, or reporting error due to, for example, different interpretations about what is being asked in deprivation (e.g. holiday, worn-out furniture or clothes) or affordability questions. Such item level invariance is especially critical when a zero threshold is applied. Therefore, for using deprivation scales with a zero threshold in the EU, a re-evaluation of certain deprivation items might be necessary.

Regardless of these issues, how can deprivation scales with a zero threshold be used? Three ways can be considered. The study is focused on the concept of (material) deprivation. As argued by Townsend (1987), deprivation is a useful sociological concept to study the consequences of inequality in resources on living conditions. The analysis reveals that even in the most affluent EU countries, a significant amount of people is deprived of certain necessities due to a lack of resources; and the risk of such deprivation is socially differentiated based on social class and education, and is significantly higher for those with lower economic resources and higher needs.

Therefore, deprivation scales with a zero threshold can be used to study the impact of inequality in resources on living conditions.

However, existing material deprivation indices are primarily designed as pragmatic tools to improve the identification of poverty and usually used alongside income poverty measures. For example, the EU poverty target measure defines those at-risk-of-poverty-or-social-exclusion as being in income poverty, low work intensity or severe material deprivation. Using a zero threshold in this context would result in very high numbers even in relatively affluent countries. This might be either due to aforementioned issues related to deprivation data or problems related to the design of existing scales. Threshold is just one part of the design and cannot be considered independent of how items are selected and aggregated. In that respect, the neglect of multidimensionality and limited availability of deprivation data are important matters. Identifying dimensions, evaluating each dimension separately with a relevant scale, and using a zero threshold at the dimensional level might provide a solution. Also, using multiple relevant items, for example, to measure deprivation in food, fuel, or social activities might also limit the measurement error arising from the aforementioned issues. Therefore, deprivation measures can be used as poverty indicators yet with a reconsideration of their design.

If proven useful for policy purposes, a third rather more pragmatic solution can be using a consistent poverty approach – a target group can be defined as those who experience income poverty and at least one deprivation from a pre-specified list of deprivation items. As argued by Maitre et al. (2013: 22), such consistent poverty measure can be useful primarily for “distinguishing a sub-set within that [target] population which merits priority in framing anti-poverty policy”. Nevertheless, in either way, advancing the quality and extent of deprivation data are the main priorities for a better measurement.

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## 7. Appendix

## **Deprivation items of Whelan & Maitre (2012) material deprivation index**

### Ability to afford

1. a meal with meat or a vegetarian alternative,
2. replacing worn-out clothes,
3. two properly fitting shoes,
4. adequate home heating,
5. spending a small amount of money each week for oneself,
6. regularly participating on a leisure activity,
7. a drink/meal with friends/relatives once a month,
8. a yearly holiday,
9. replacing worn-out furniture.

**Table A1: Missing data for variables of interest in the whole sample**

<b>Variables</b>	<b># of missing cases</b>	<b>% of missing cases</b>	<b>Mean</b>	<b>Sd</b>	<b>Min</b>	<b>Max</b>	<b>Sample size</b>
Deprivation index	4,887	2.25	1.54	2.10	0	9	217,170
MDholiday	261	0.12	0.39	0.49	0	1	217,170
MDmeat	114	0.05	0.11	0.31	0	1	217,170
MDwarm	133	0.06	0.10	0.31	0	1	217,170
MDrefurnish	2,504	1.15	0.32	0.47	0	1	217,170
MDcloth	3,595	1.66	0.12	0.33	0	1	217,170
MDshoes	3,585	1.65	0.03	0.16	0	1	217,170
MDg_out	3,593	1.65	0.14	0.34	0	1	217,170
MDleisure	3,585	1.65	0.17	0.37	0	1	217,170
MDsmoney	3,689	1.70	0.16	0.36	0	1	217,170
Social class (ESEC 5)	2,105	0.97	3.05	1.72	1	6	217,170
Education (ISCED 3)	1,918	0.88	2.12	0.74	1	3	217,170
Income ( <i>eq. disposable</i> )	0	0.00	16717	16124	-589401	747474	217,170
Female	0	0.00	0.40	0.49	0	1	217,170
Unemployment	1,010	0.47	0.05	0.21	0	1	217,170
Single parenthood	66	0.03	0.04	0.19	0	1	217,170
Divorced	929	0.43	0.11	0.31	0	1	217,170
Chronic health problem in HH	783	0.36	0.46	0.50	0	1	217,170
Disability problem in HH	873	0.40	0.39	0.49	0	1	217,170
Having three children	0	0.00	0.03	0.18	0	1	217,170
Renter	36	0.02	0.19	0.39	0	1	217,170

**Table A2: % of missing in deprivation index and social class for each country**

Country	Deprivation index	Social class	Education
AT	0.27	2.70	0.00
BE	0.34	0.96	0.49
BG	0.02	0.61	0.02
CY	0.00	0.00	0.00
CZ	0.00	0.54	0.00
DE	3.41	0.63	0.14
DK	0.66	2.93	1.86
EE	0.58	0.34	0.50
EL	0.14	0.00	0.14
ES	0.49	0.66	0.51
FI	0.77	0.15	1.24
FR	1.39	2.07	0.15
HU	0.13	0.05	0.00
IE	0.17	0.10	1.74
IT	1.25	0.55	1.25
LT	0.12	0.00	0.10
LU	0.54	0.09	0.21
LV	0.52	0.17	0.52
MT	4.13	0.66	0.11
NL	0.87	3.27	0.73
PL	3.53	0.06	3.55
PT	1.55	0.14	0.10
RO	0.08	0.00	0.08
SE	29.55	3.59	0.62
SI	0.00	3.11	0.00
SK	0.32	0.32	0.25
UK	7.82	1.54	5.95
Total	2.25	0.97	0.88

**Table A3: Model selection between PM, NBM, HPM and HNBM – AIC, BIC**

		PM	NBM	HPM	HNBM	OLS	Preferred
DENMARK	AIC	7466	6487	6462	6385	13545	HNBM
	BIC	7604	6632	6701	6629	13684	HNBM
FINLAND	AIC	14720	13289	13090	12997	25505	HNBM
	BIC	14871	13447	13357	13270	25656	HNBM
NETHERLANDS	AIC	14764	13319	13064	13003	25424	HNBM
	BIC	14913	13476	13331	13276	25574	HNBM
LUXEMBOURG	AIC	7340	6495	6364	6273	13221	HNBM
	BIC	7473	6635	6600	6514	13354	HNBM
AUSTRIA	AIC	14211	12323	12126	11974	19896	HNBM
	BIC	14351	12469	12382	12235	20036	HNBM
UK	AIC	19317	17131	16620	16482	26632	HNBM
	BIC	19463	17284	16889	16757	26778	HNBM
BELGIUM	AIC	15979	13990	13759	13526	21903	HNBM
	BIC	16120	14138	14019	13792	22044	HNBM
GERMANY	AIC	35500	30784	29390	29197	46098	HNBM
	BIC	35657	30948	29682	29495	46254	HNBM
IRELAND	AIC	12192	11460	11331	11166	16584	HNBM
	BIC	12329	11604	11586	11427	16721	HNBM
FRANCE	AIC	28196	25814	25304	25047	37274	HNBM
	BIC	28348	25973	25590	25338	37426	HNBM
ITALY	AIC	56598	51518	52020	50621	72659	HNBM
	BIC	56764	51692	52336	50944	72825	HNBM
SPAIN	AIC	36075	34584	34269	33982	44668	HNBM
	BIC	36232	34748	34568	34289	44825	HNBM
SLOVENIA	AIC	27864	26023	25731	25527	33544	HNBM
	BIC	28013	26179	26015	25818	33693	HNBM
CZECH REPUBLIC	AIC	29561	29068	28710	28644	34394	HNBM
	BIC	29712	29226	29002	28943	34545	HNBM
CYPRUS	AIC	9443	9371	9180	12729	10873	HPM
	BIC	9570	9504	9425	12989	11000	HPM
ESTONIA	AIC	15312	15024	14893	14843	17372	HNBM
	BIC	15449	15167	15157	15113	17508	HNBM
GREECE	AIC	21837	21416	20833	20802	25061	HNBM
	BIC	21981	21567	21111	21087	25204	HNBM
SLOVAKIA	AIC	17502	17099	16851	16777	19517	HNBM
	BIC	17640	17243	17118	17050	19655	HNBM
POLAND	AIC	47276	45593	45332	44727	52077	HNBM

	BIC	47433	45757	45638	45040	52234	HNBM
PORTUGAL	AIC	19046	18514	18064	17987	20438	HNBM
	BIC	19183	18657	18330	18260	20574	HNBM
LITHUANIA	AIC	20767	19901	19922	19706	21678	HNBM
	BIC	20904	20044	20190	19980	21815	HNBM
HUNGARY	AIC	40543	39540	38790	38640	41306	HNBM
	BIC	40693	39698	39087	38944	41457	HNBM
LATVIA	AIC	23683	23278	23148	23056	24341	HNBM
	BIC	23823	23424	23423	23338	24481	HNBM
ROMANIA	AIC	33378	33258	32312	32314	33217	HPM
	BIC	33524	33411	32601	32610	33363	HPM
BULGARIA	AIC	24558	24560	23962	23964	23880	OLS
	BIC	24697	24705	24238	24247	24019	OLS

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*Notes: Lower values of information criteria (AIC, BIC) shows better fit. The results show a strong preference for HNBM.*

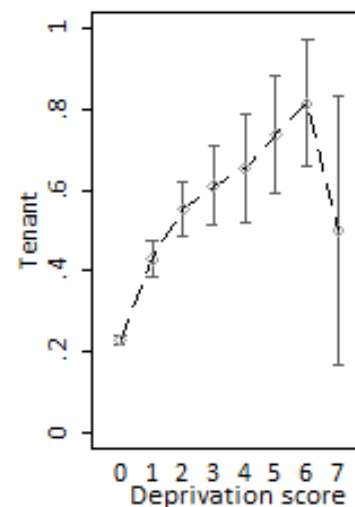
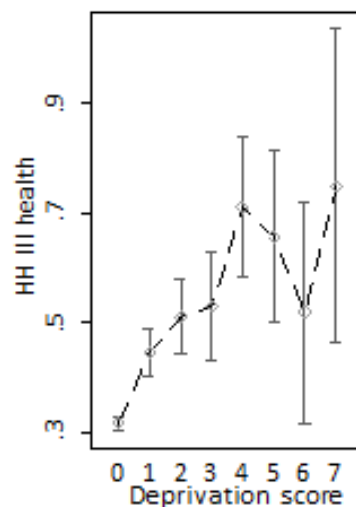
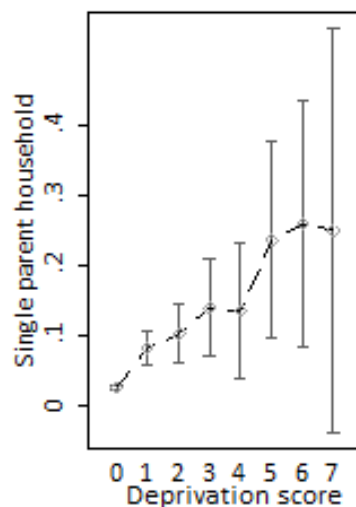
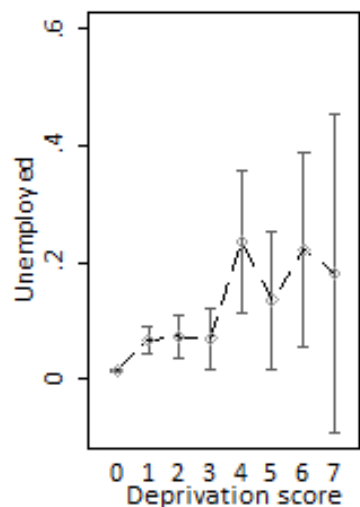
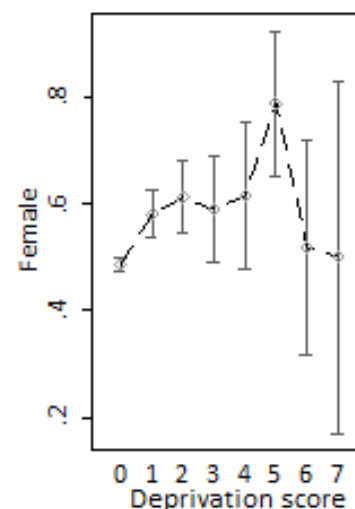
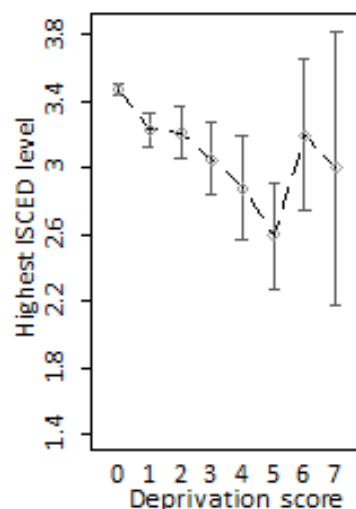
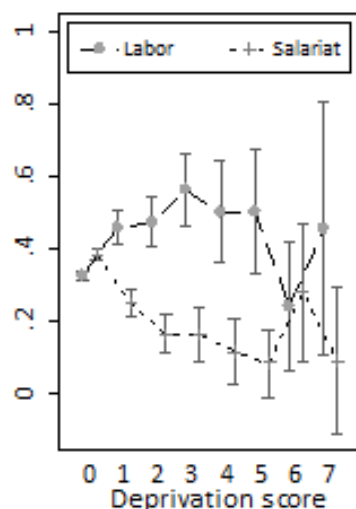
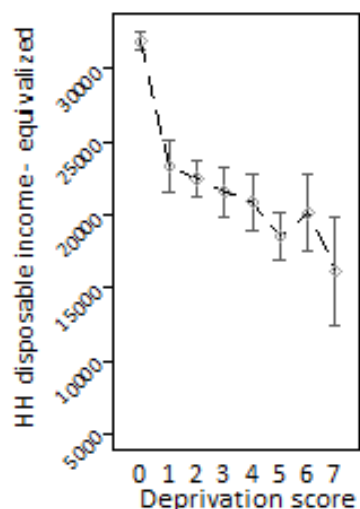
## **8. Supplementary material for “Understanding material deprivation for 25 EU countries – risk and level perspective and distinctiveness of zeros”**

This supplementary material includes four sections: i) exploratory graphs examining the risk profiles of deprivation groups for each risk factors and for each country; ii) the results of the statistical tests comparing counts models for the weighted WM index and 13 item Guio index; iii) the graphs showing social class variation on the risk and the level of deprivation for the remaining 21 countries, and iv) the full results of the determinants of risk and level of deprivation for all countries.

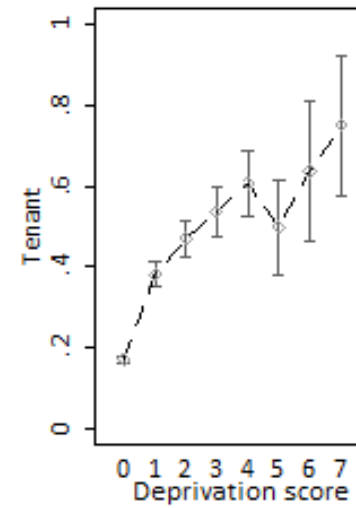
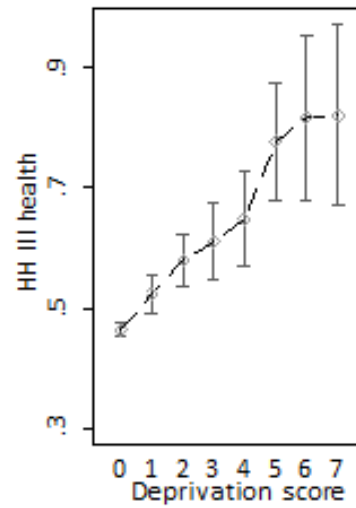
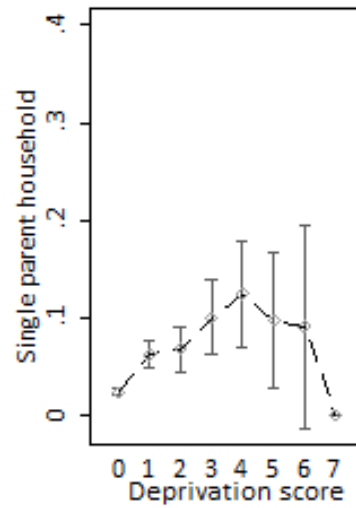
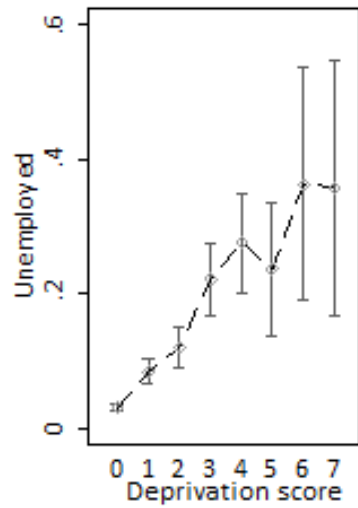
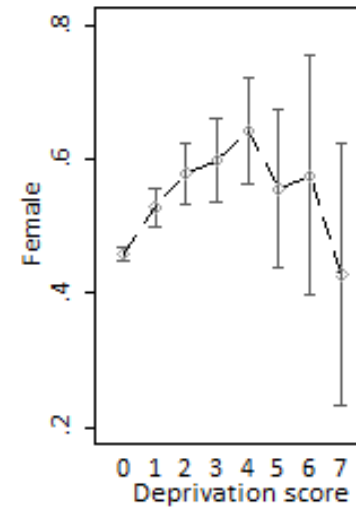
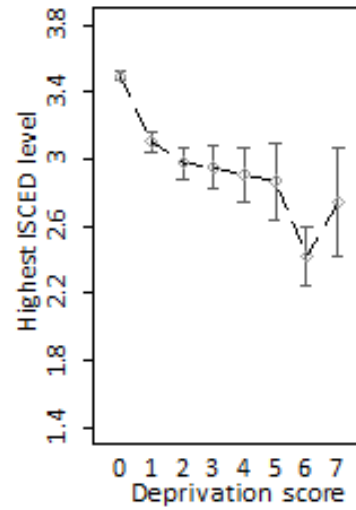
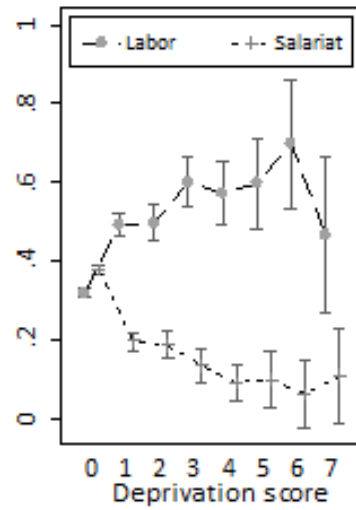
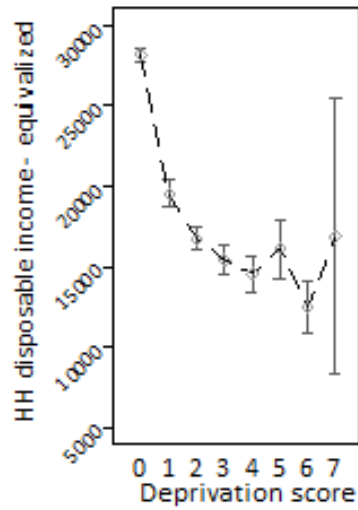
## **S1: Exploratory data analysis – risk profiles of deprivation groups for 25 EU countries**

The following graphs show the average incidence of risk factors for each deprivation groups for all fourteen EU countries. The risk factors are income, social class, education, gender, unemployment, single parenthood, ill health and house ownership. Ill health is defined as having either a chronic health or a disability problem. The figures show confidence interval plot, hence point estimates and 95% confidence intervals for the average incidence. For almost all countries, the results show a curve linear trend for the key risk factors such as income, social class, education and ill health, where the zero deprivation group has a significantly lower (or higher) risk incidence which rises significantly for the first count and slightly increases for the subsequent counts. Also for other factors, zero deprivation group always has the lowest risk incidence. These results point out that i) zeros are significantly different than count groups, ii) count groups, in average, have very similar risk profiles, and hence when deprivation is assumed binary, the most meaningful distinction can be made between zeros and counts; iii) the main part of the variance comes from the differences between zeros and counts and not from the differences among counts.

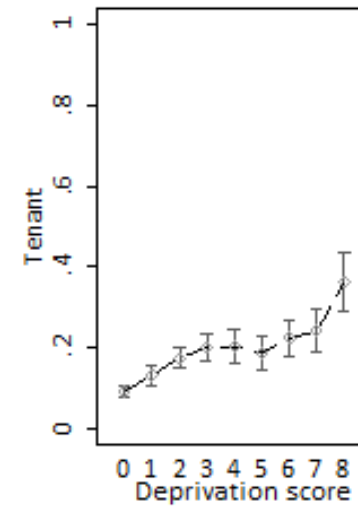
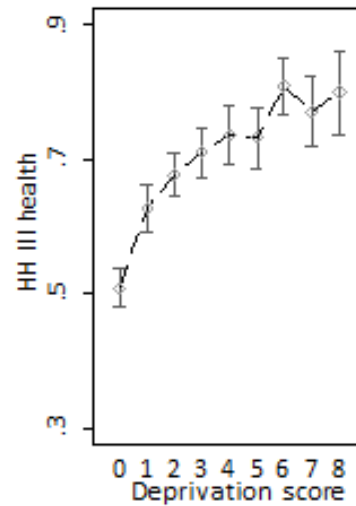
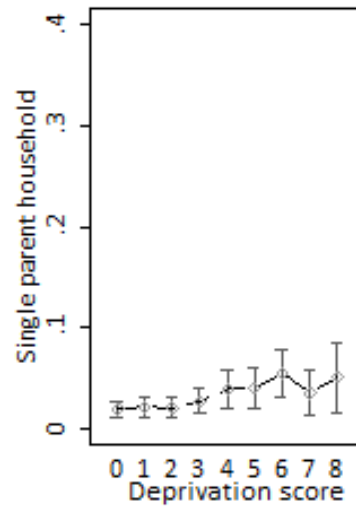
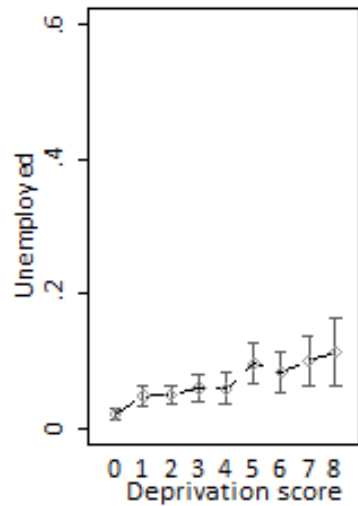
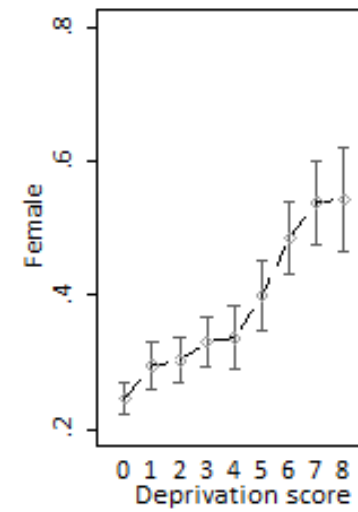
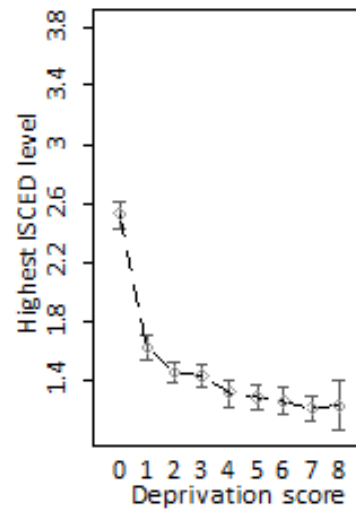
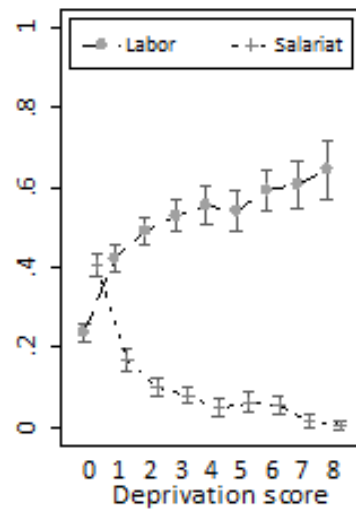
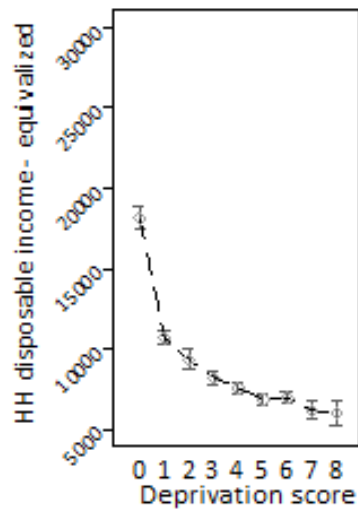
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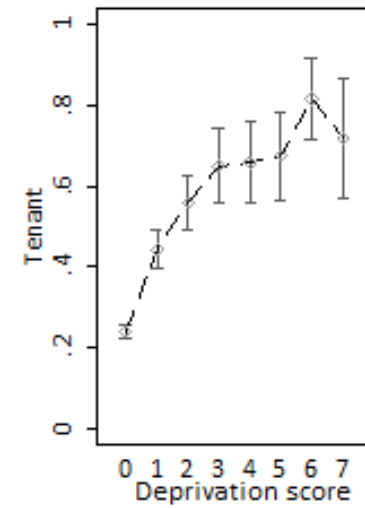
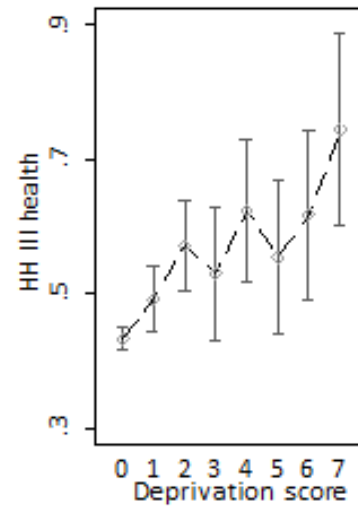
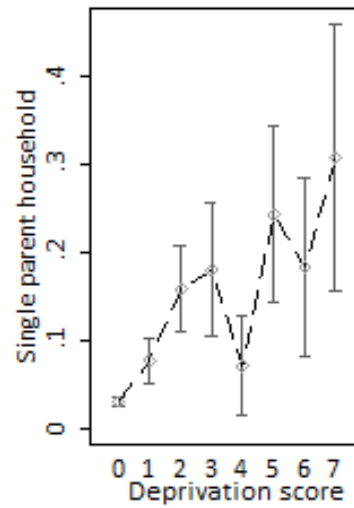
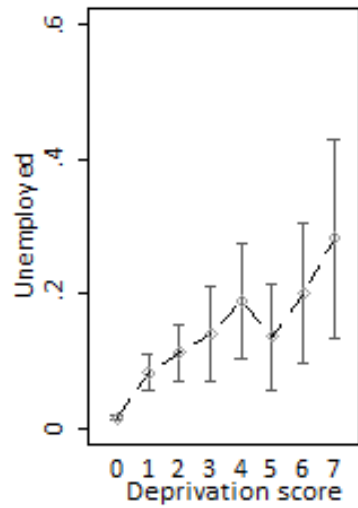
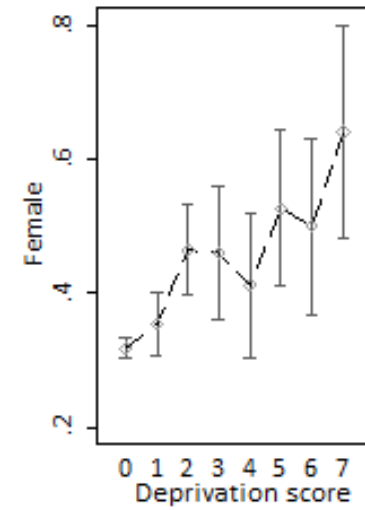
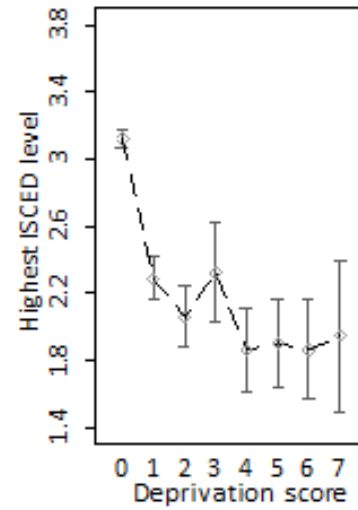
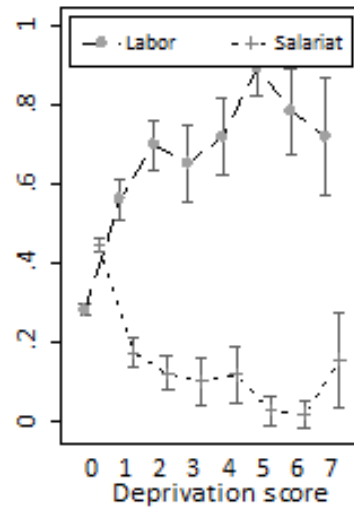
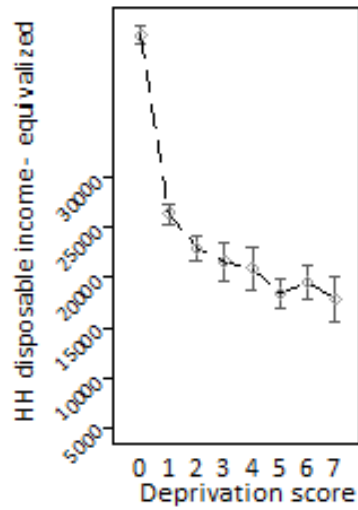
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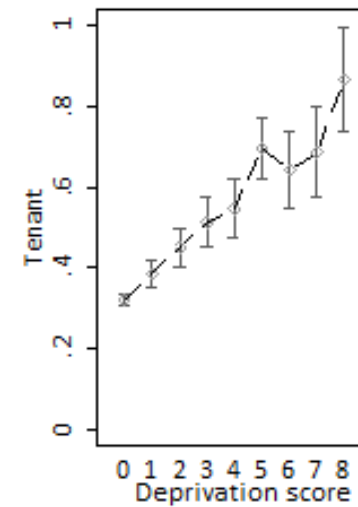
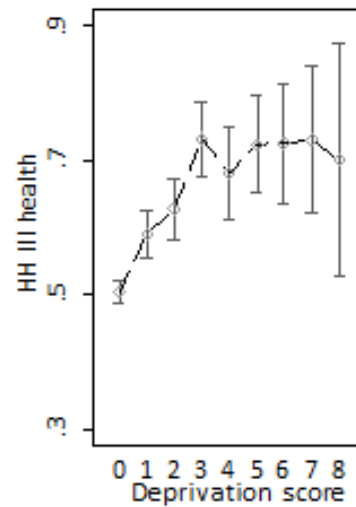
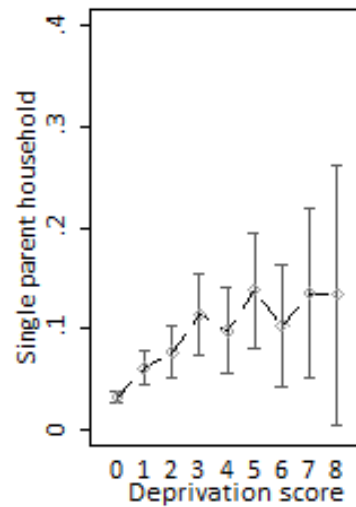
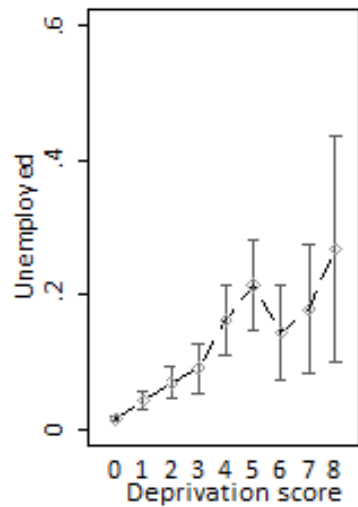
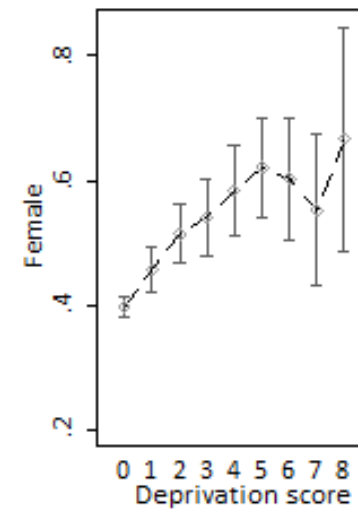
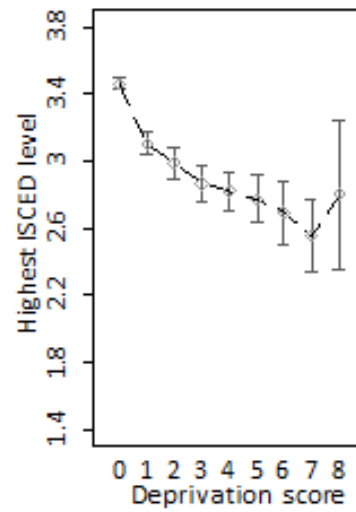
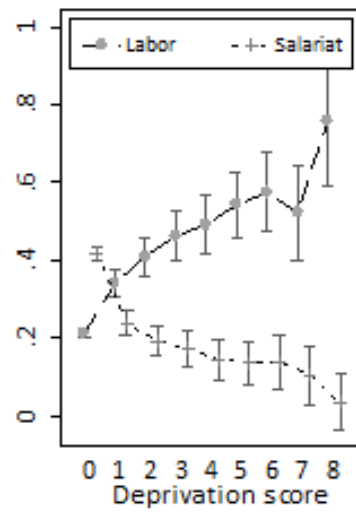
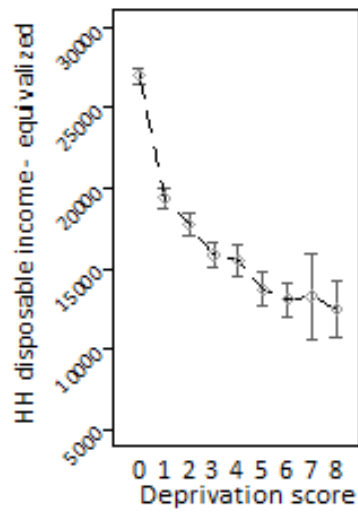
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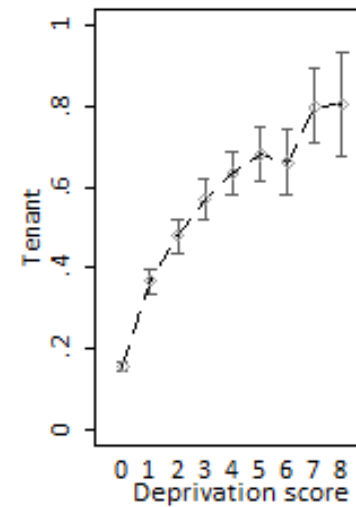
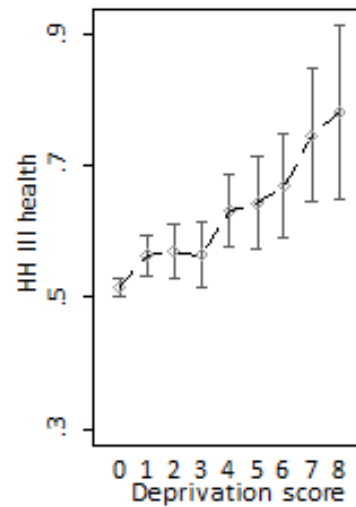
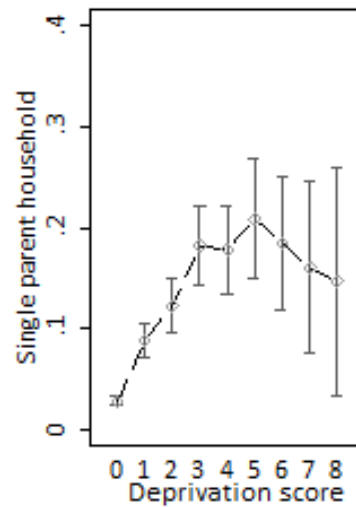
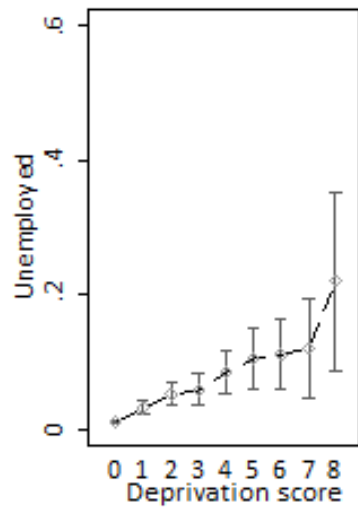
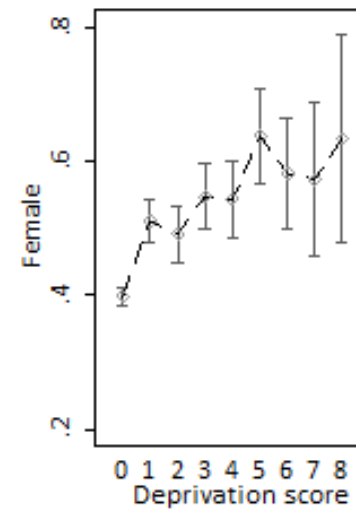
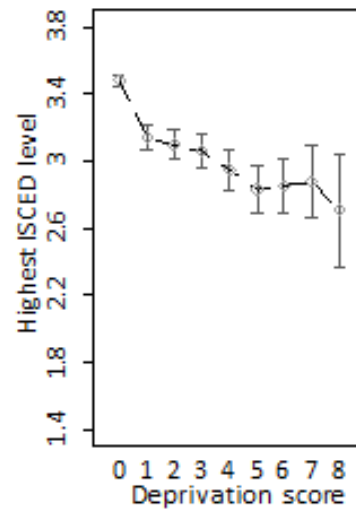
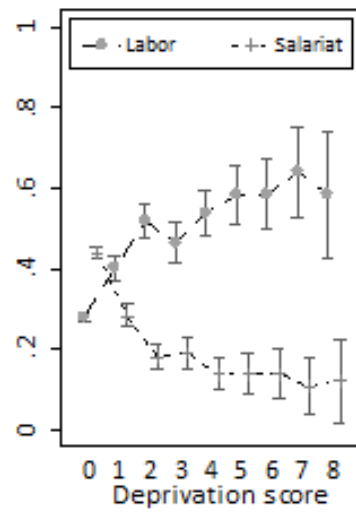
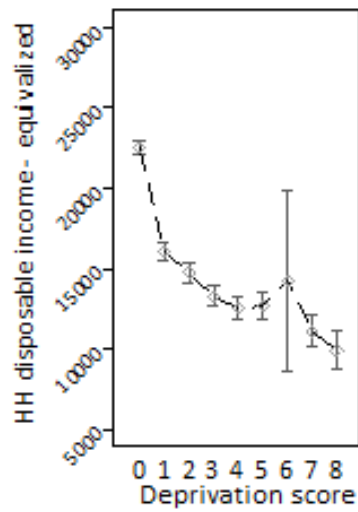
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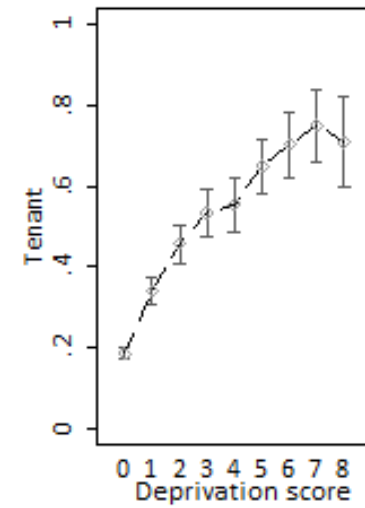
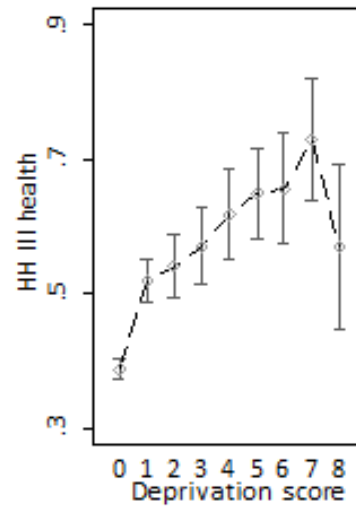
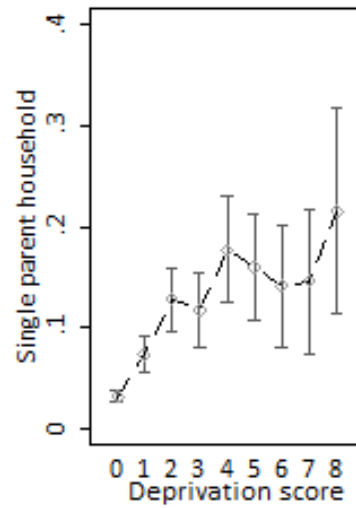
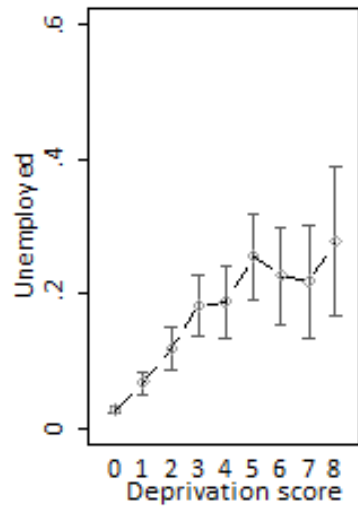
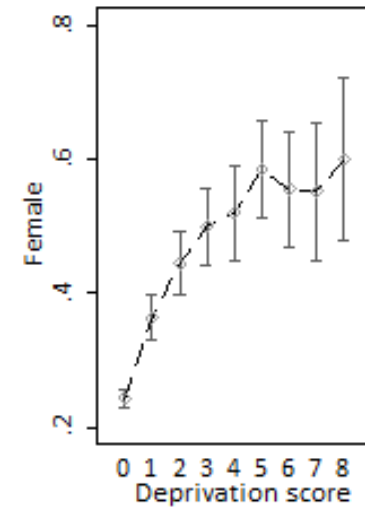
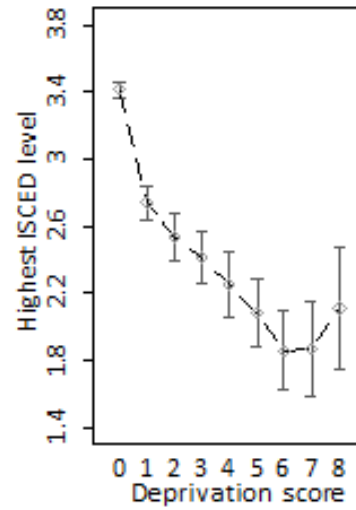
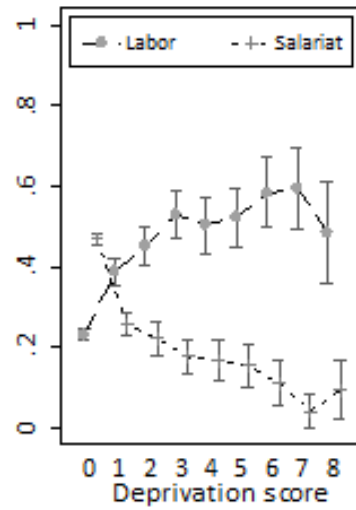
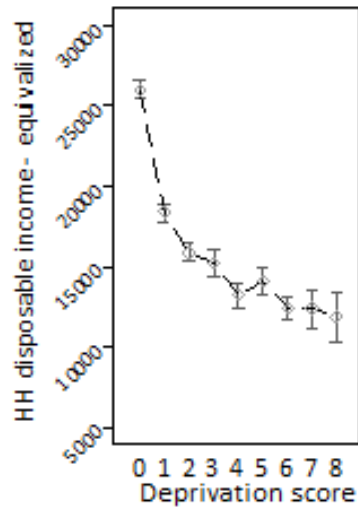
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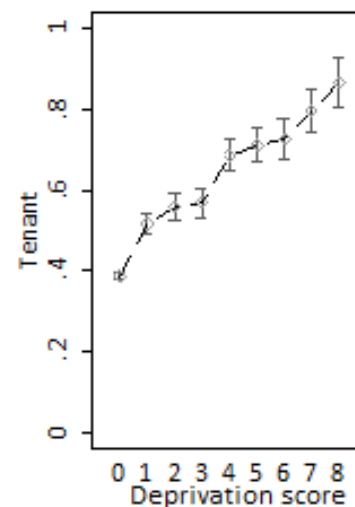
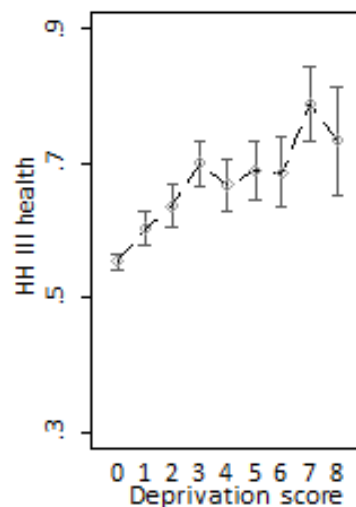
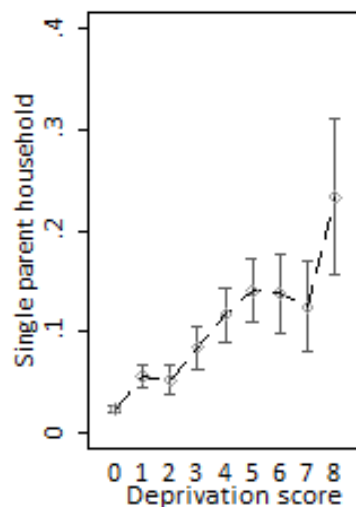
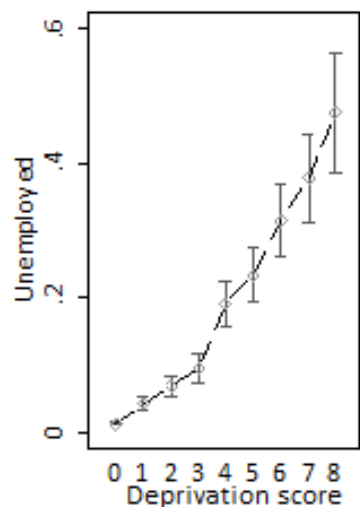
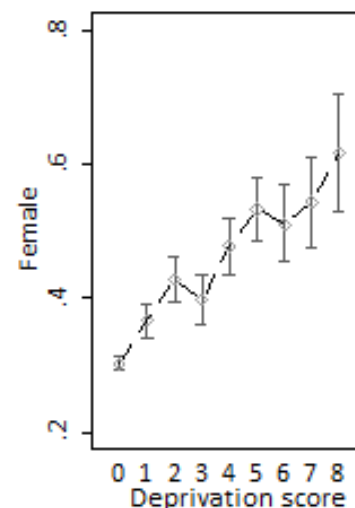
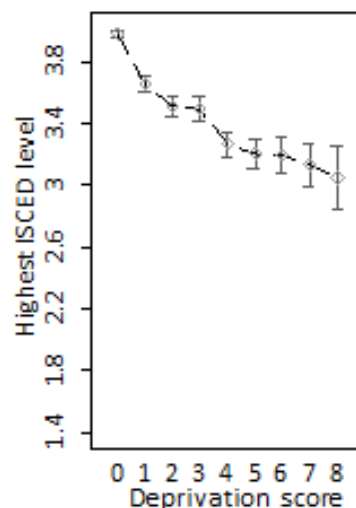
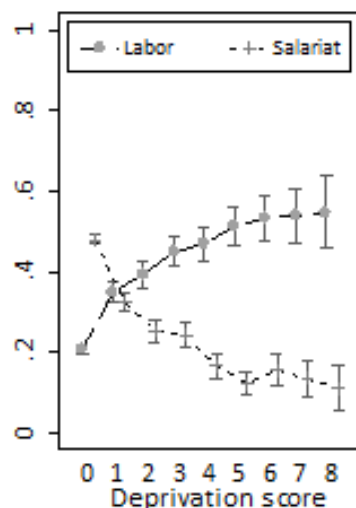
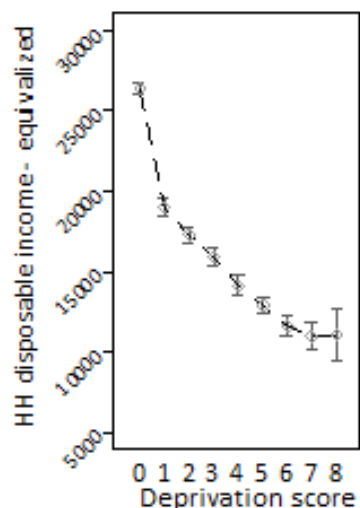
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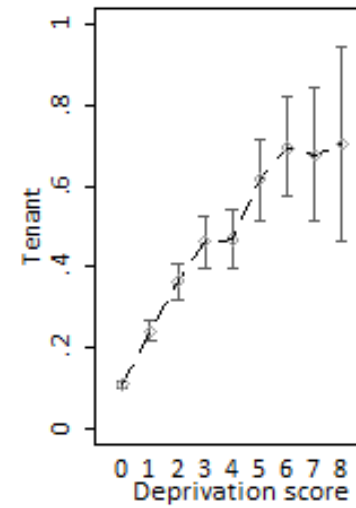
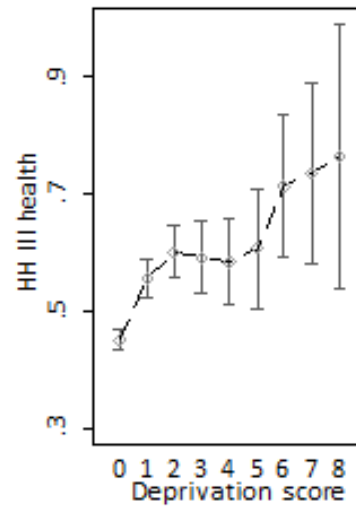
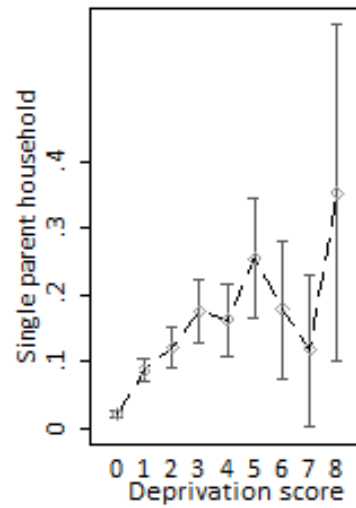
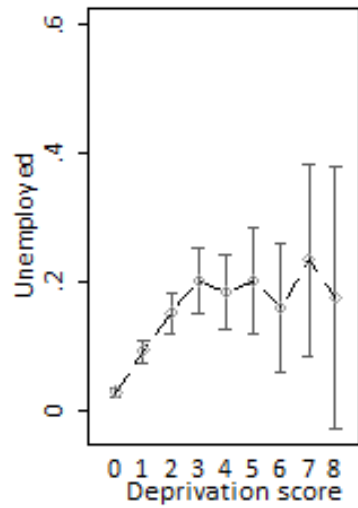
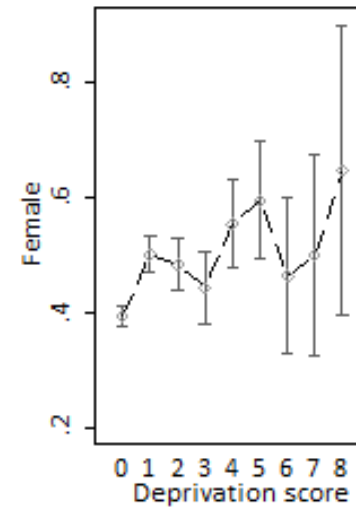
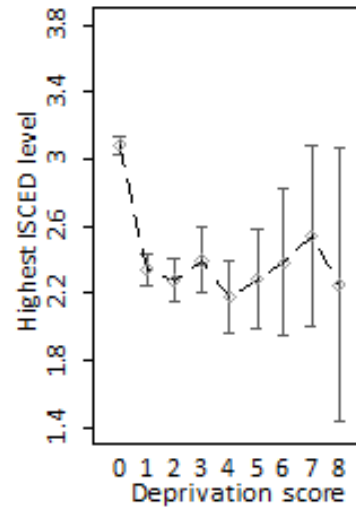
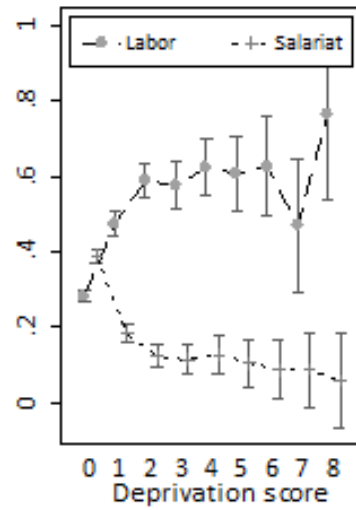
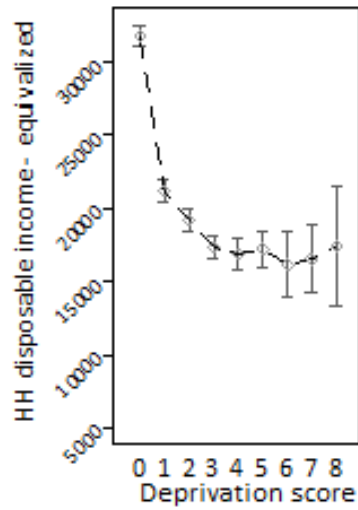
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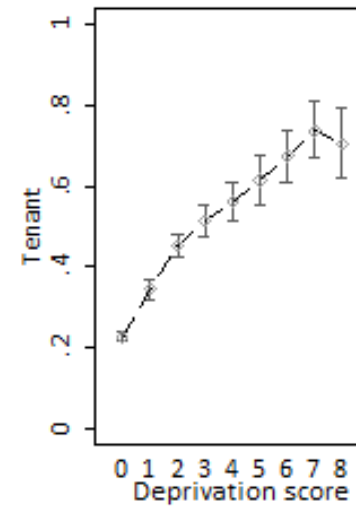
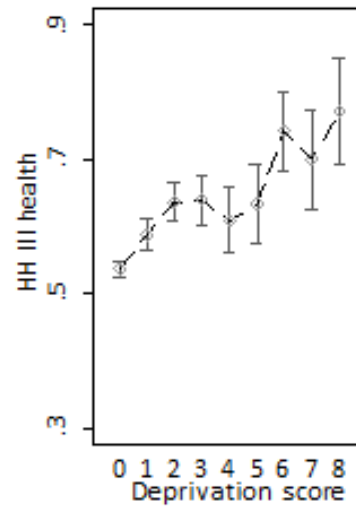
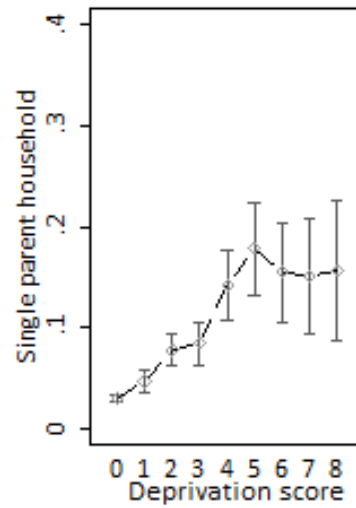
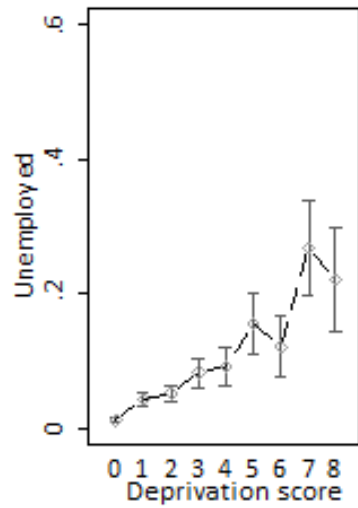
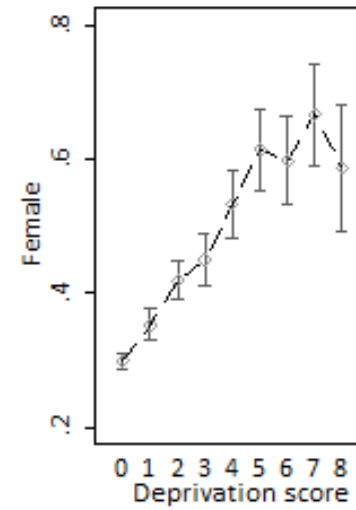
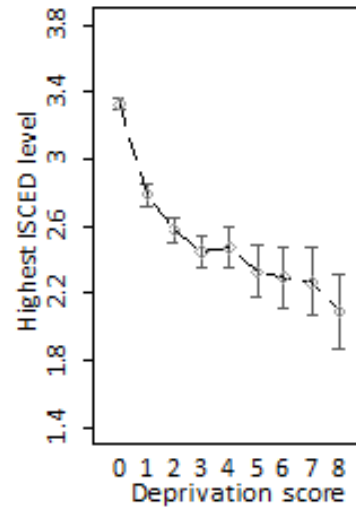
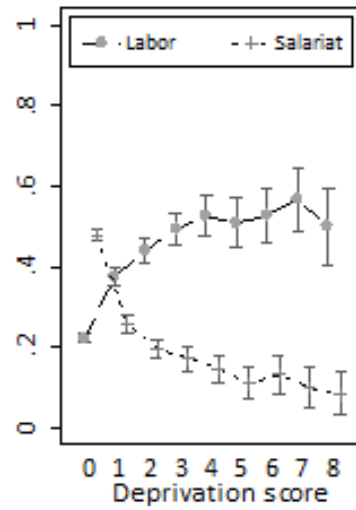
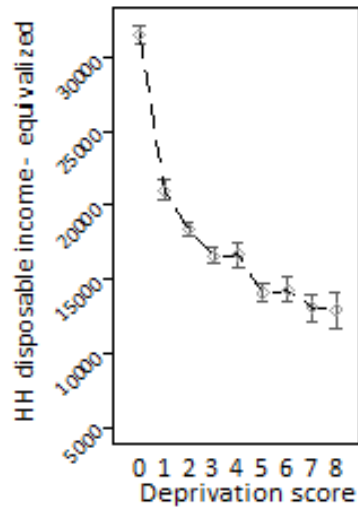
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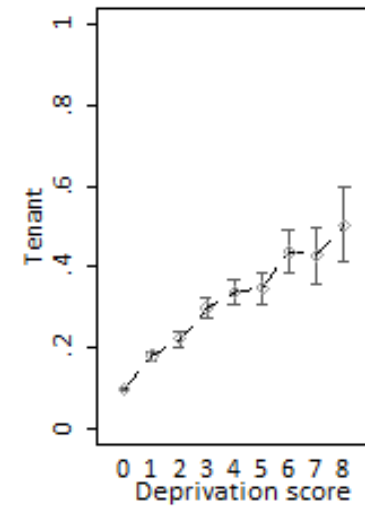
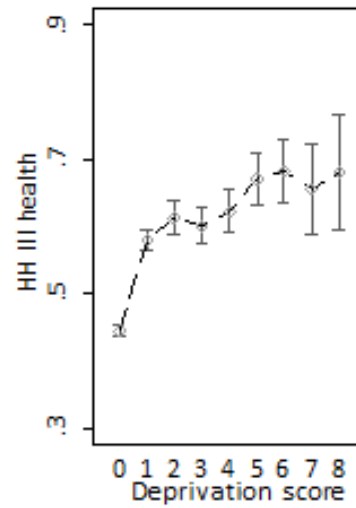
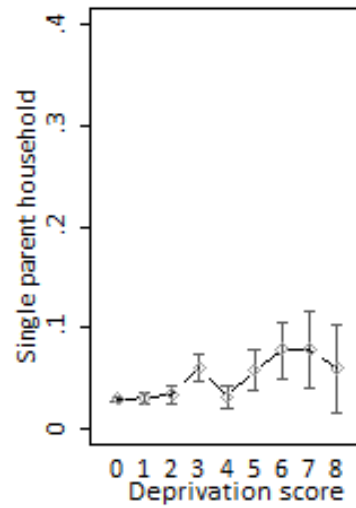
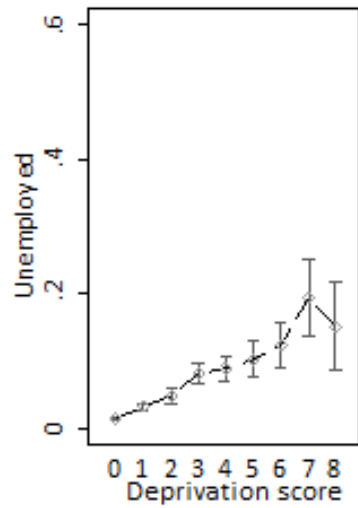
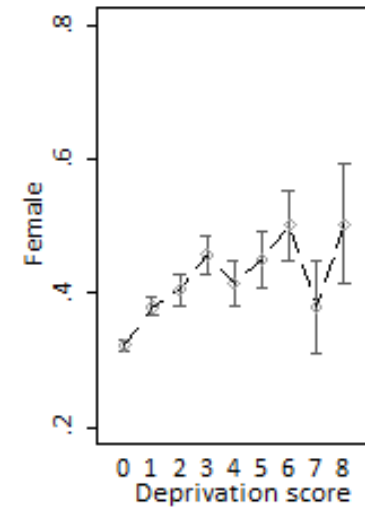
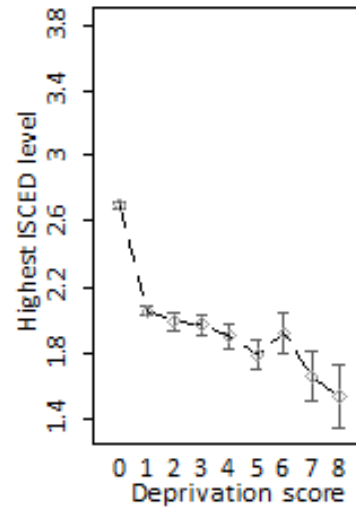
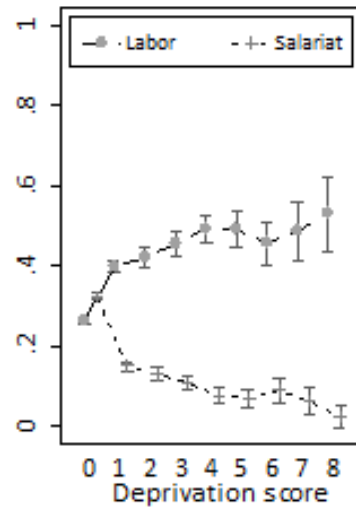
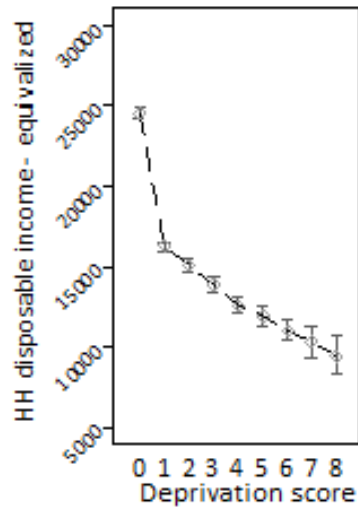
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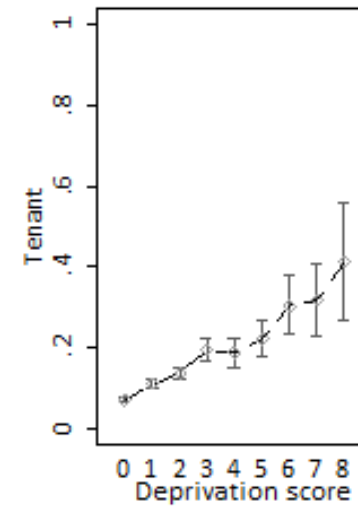
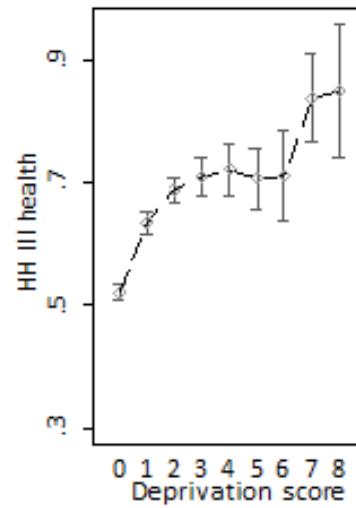
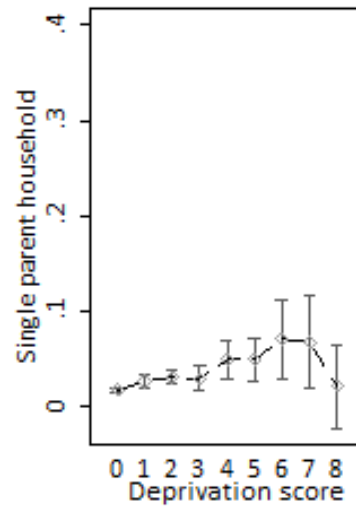
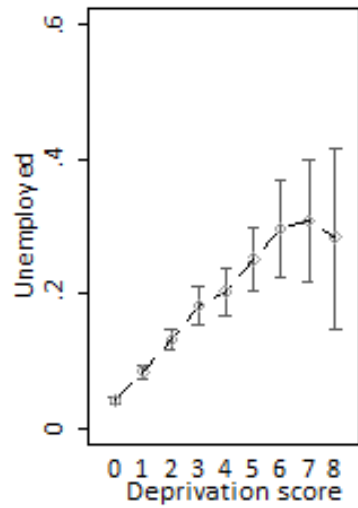
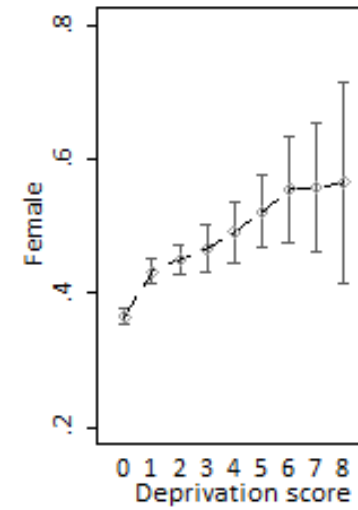
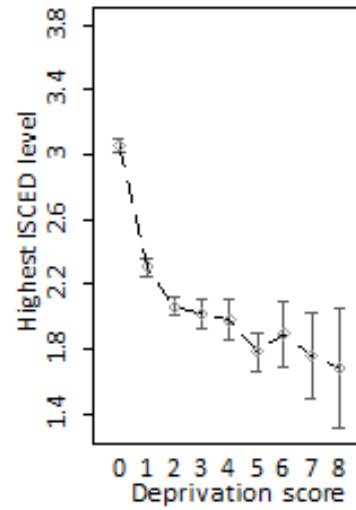
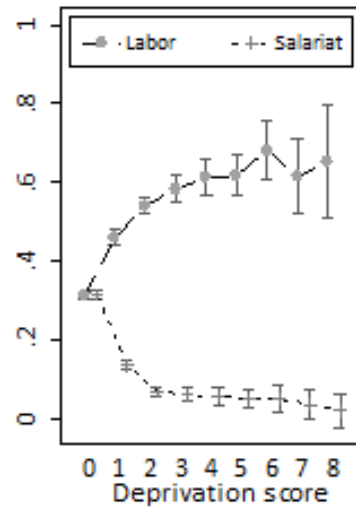
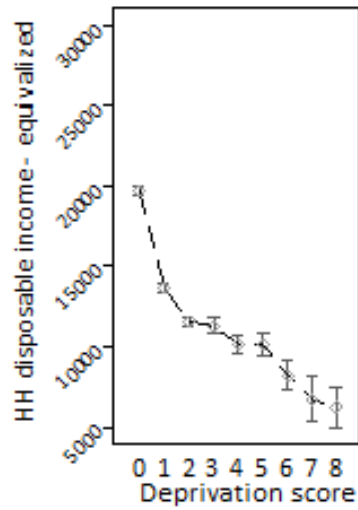
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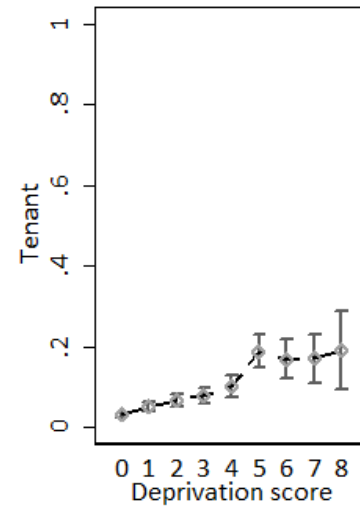
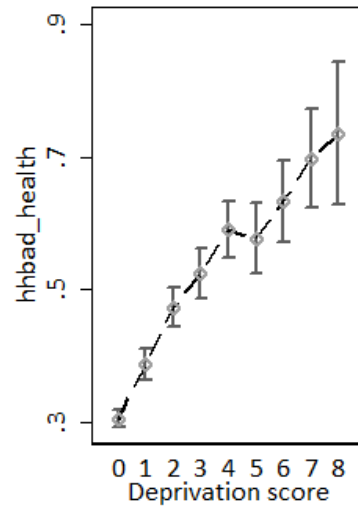
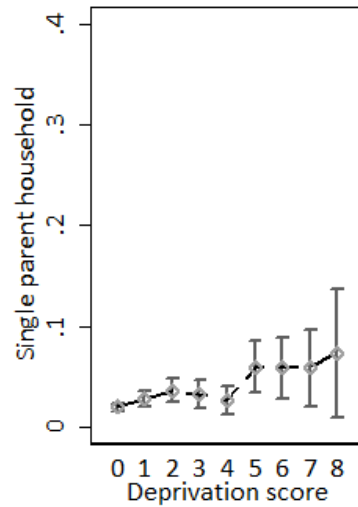
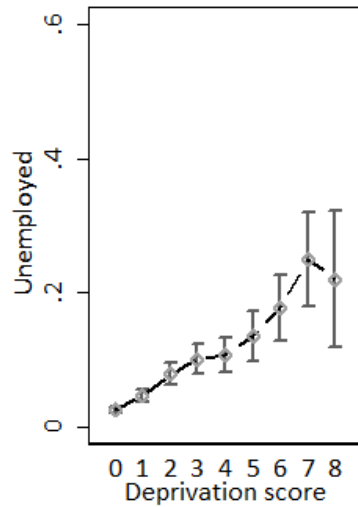
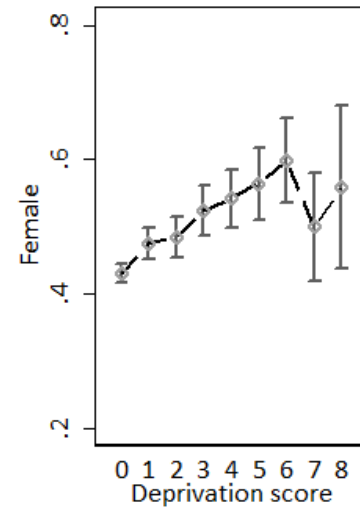
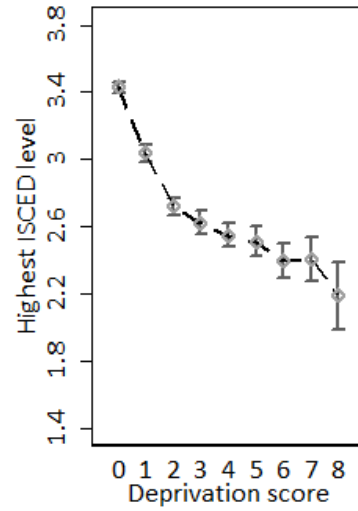
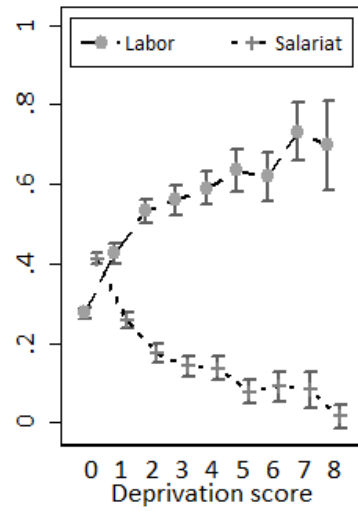
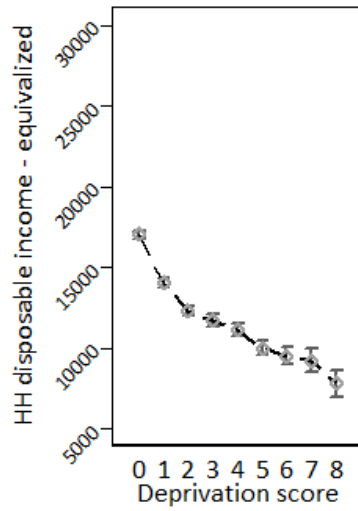
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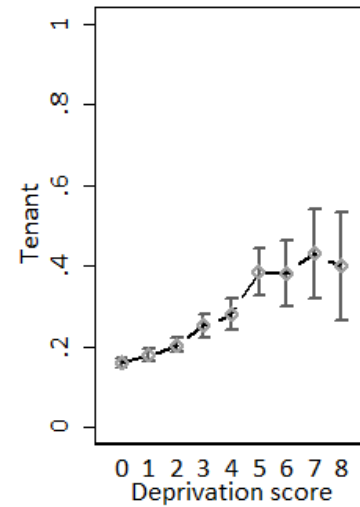
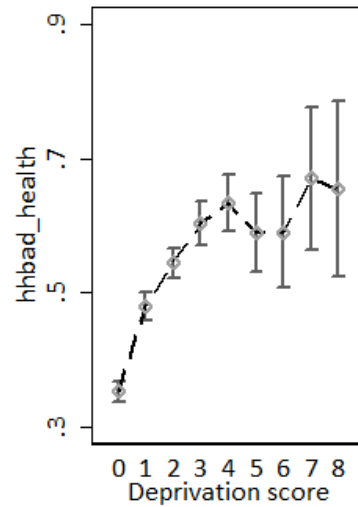
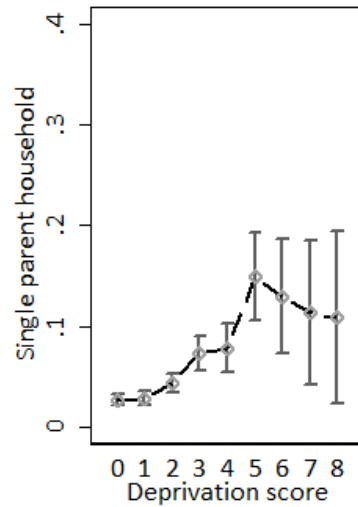
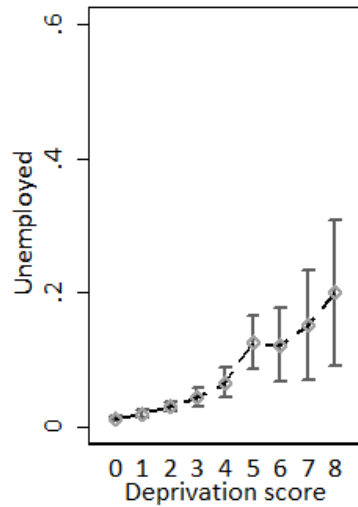
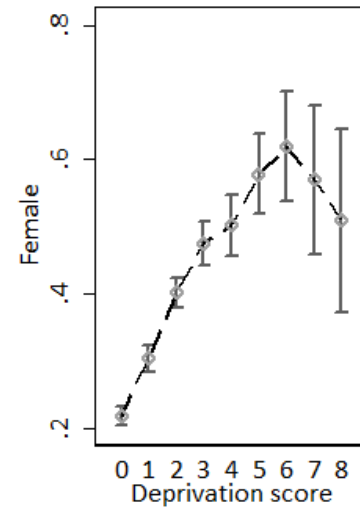
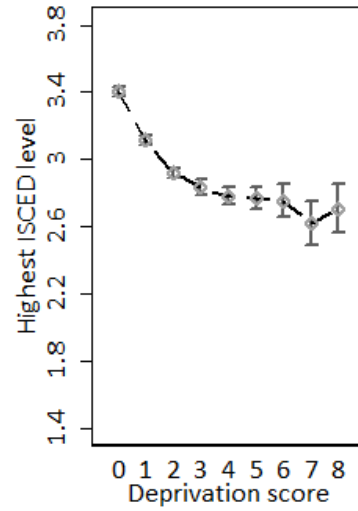
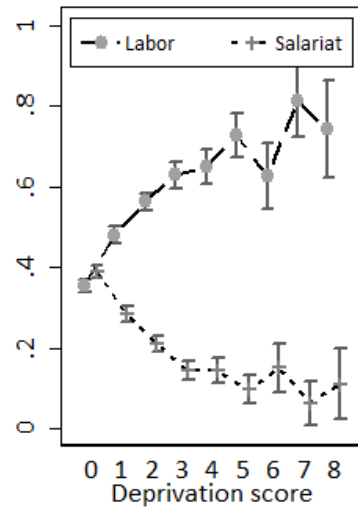
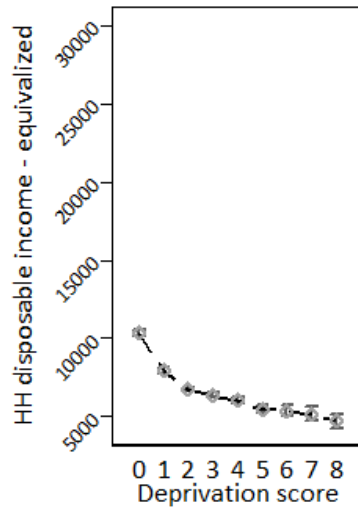
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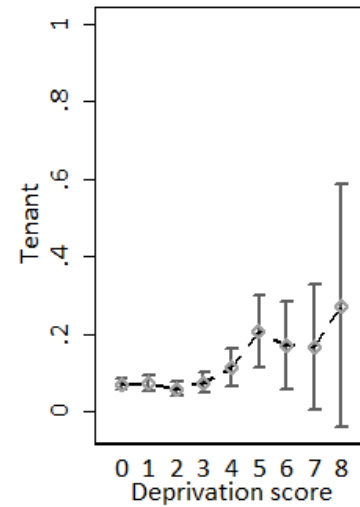
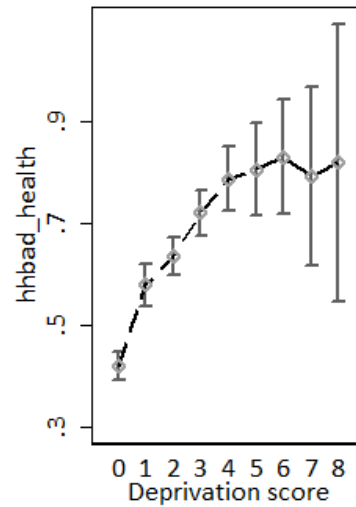
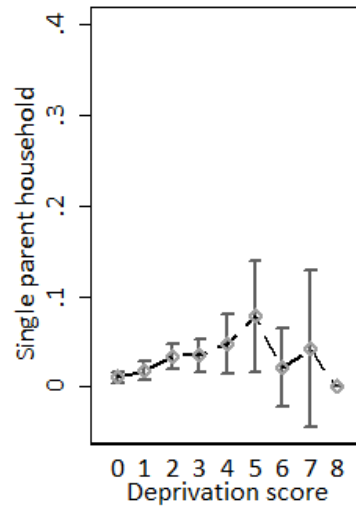
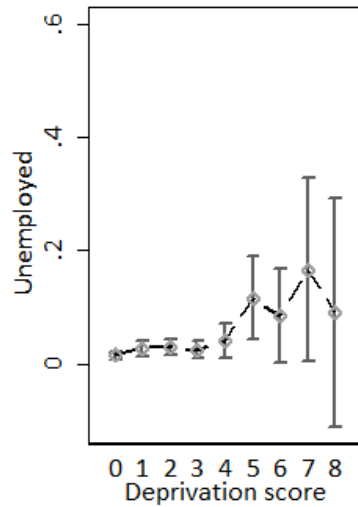
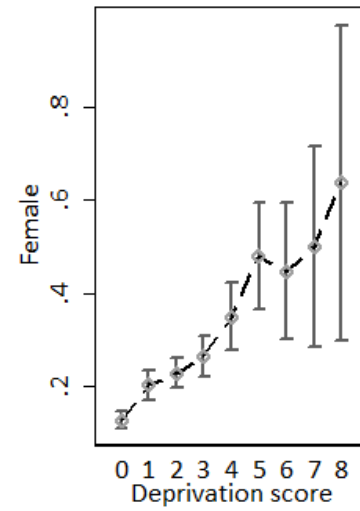
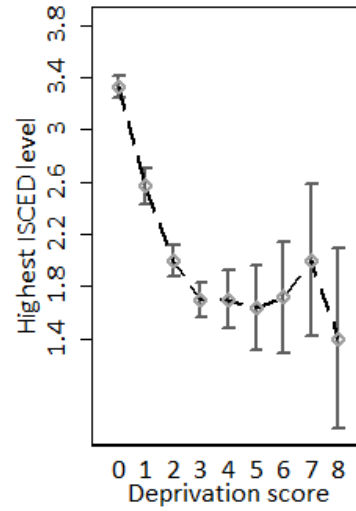
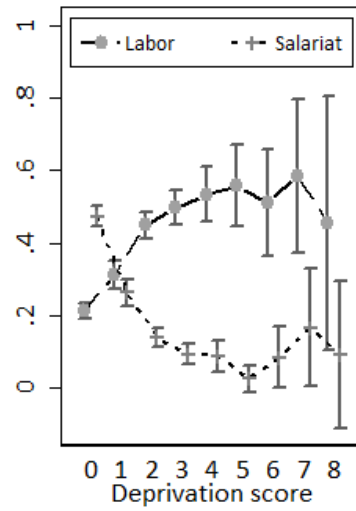
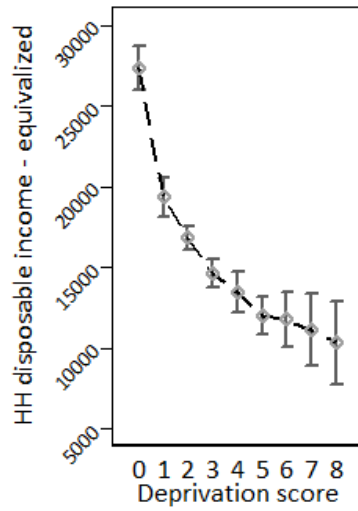
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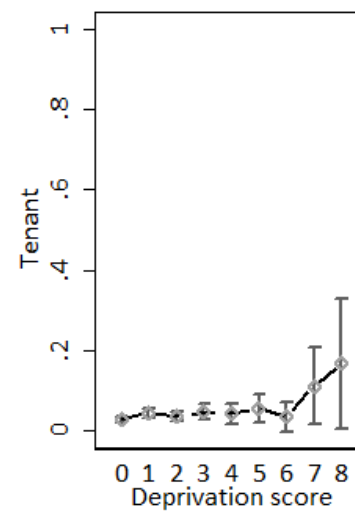
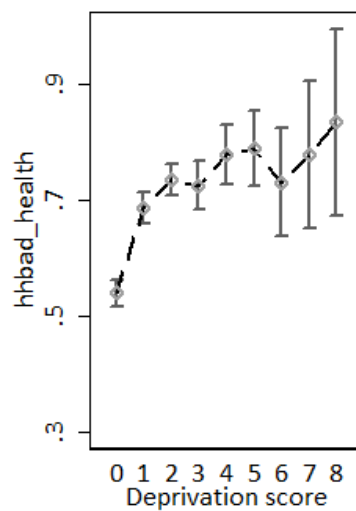
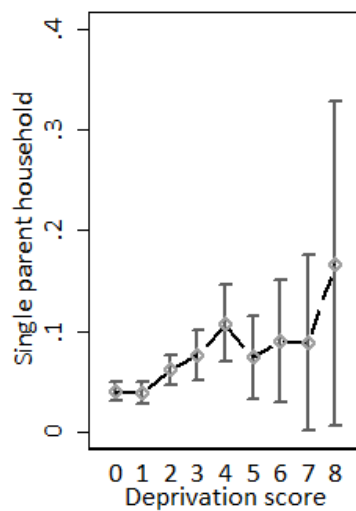
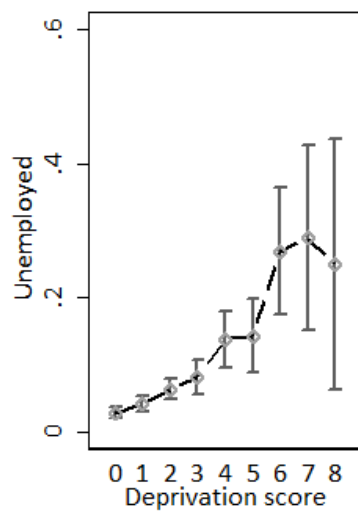
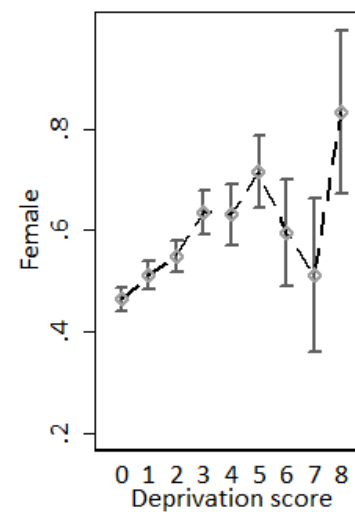
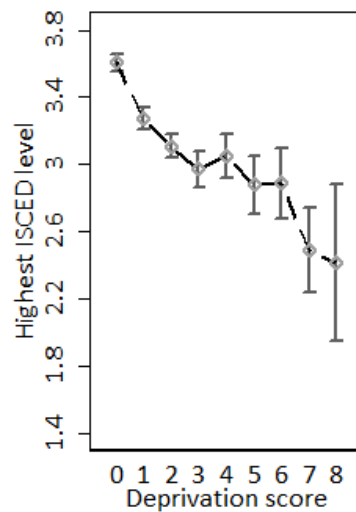
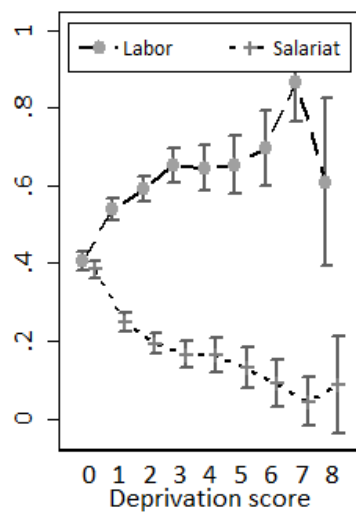
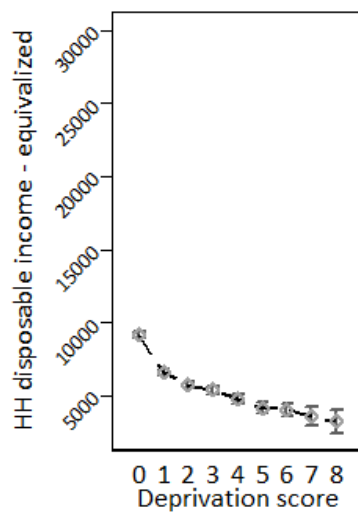
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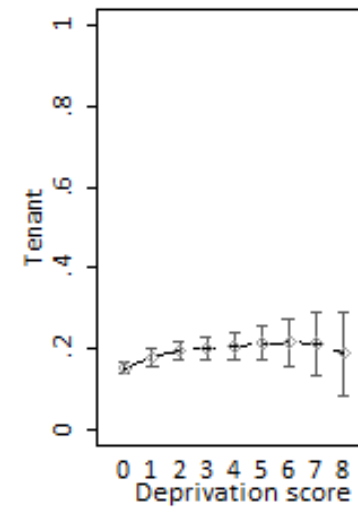
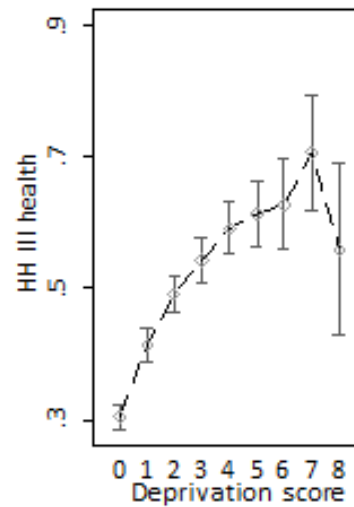
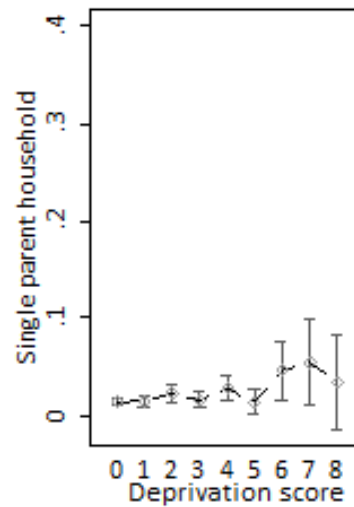
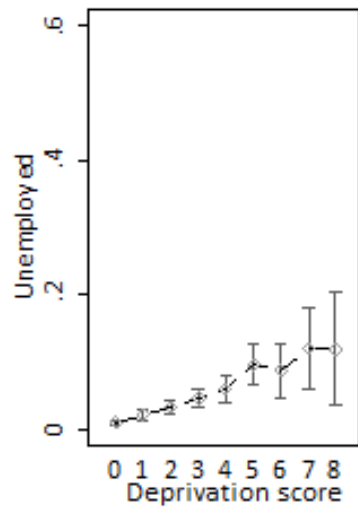
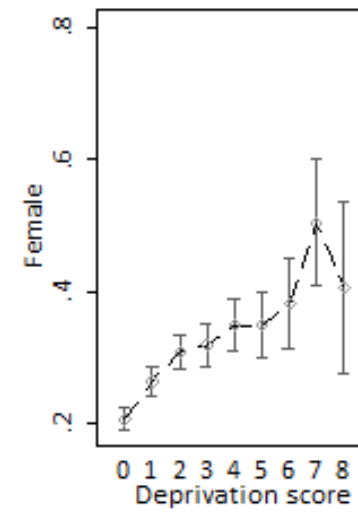
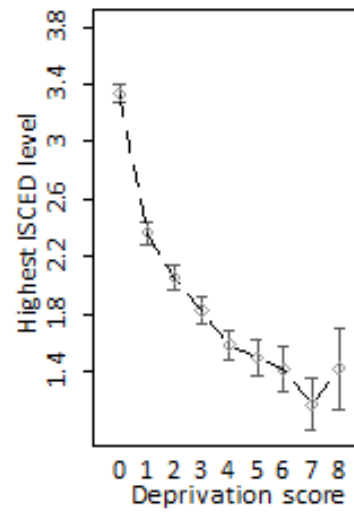
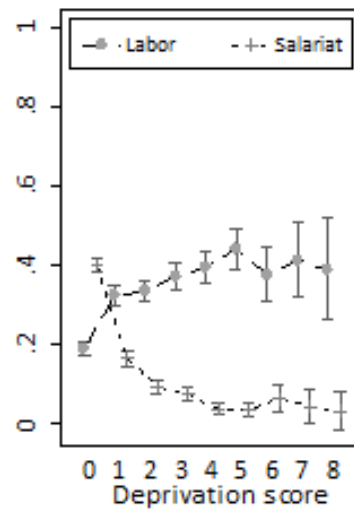
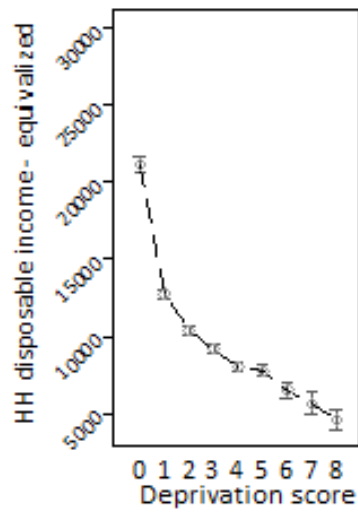
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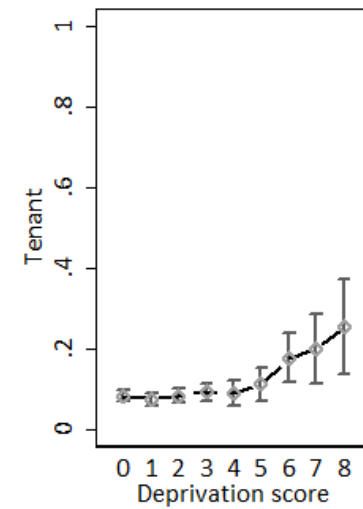
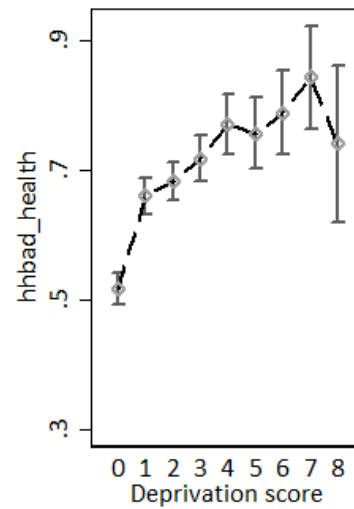
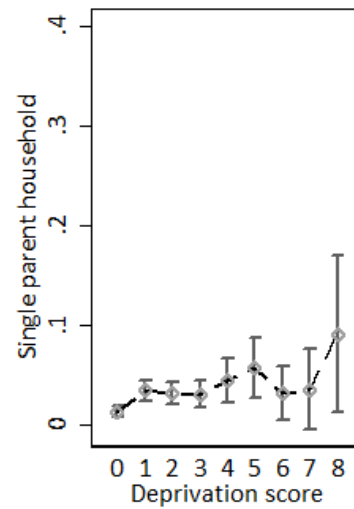
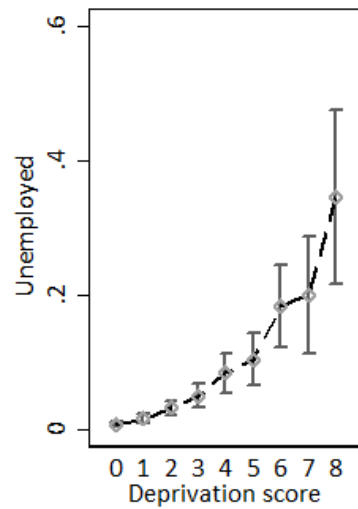
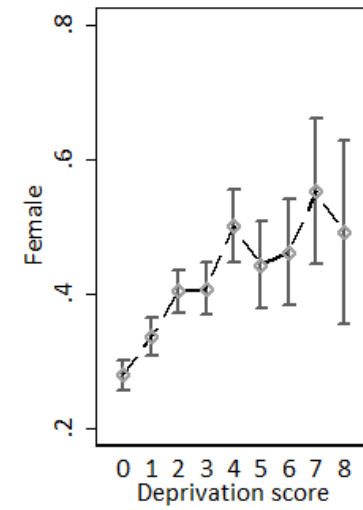
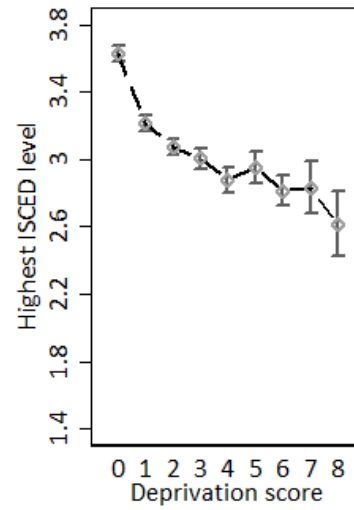
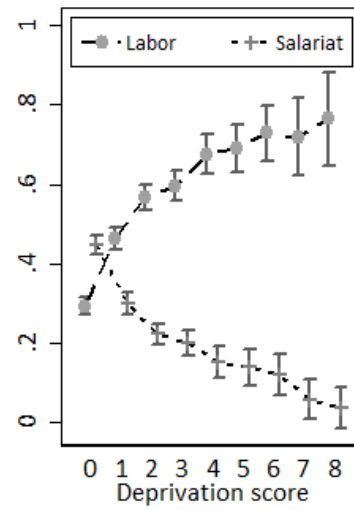
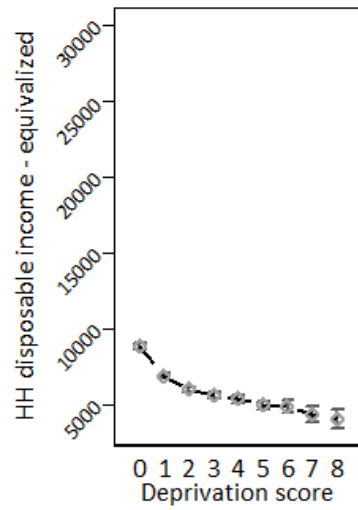
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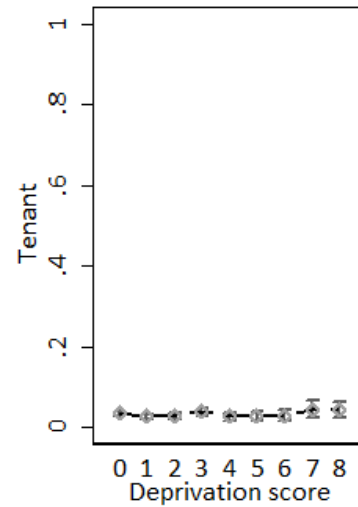
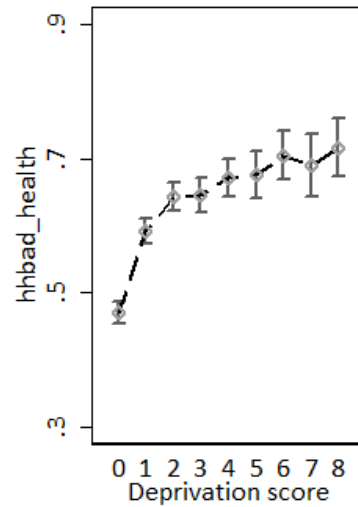
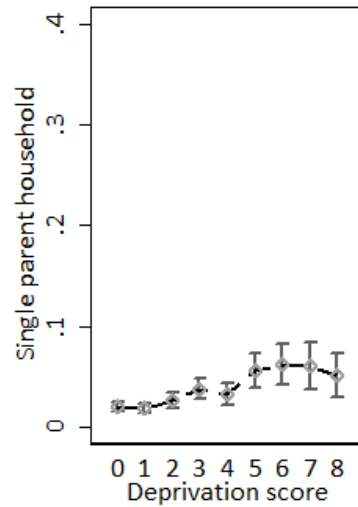
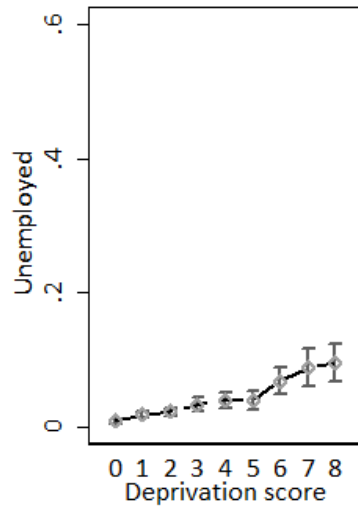
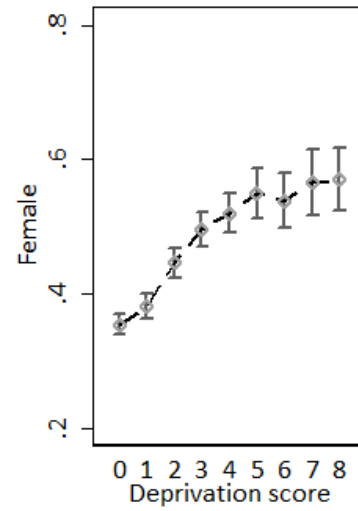
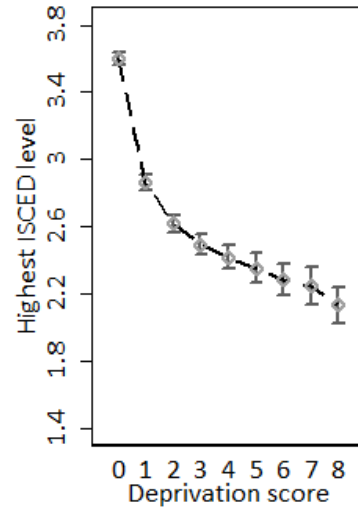
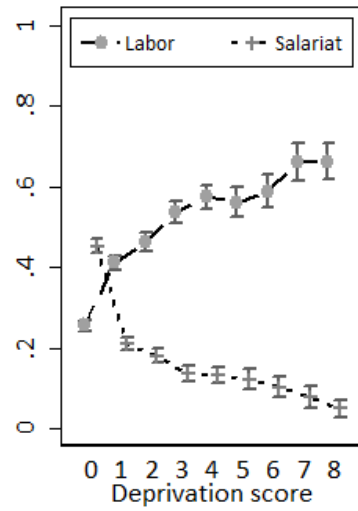
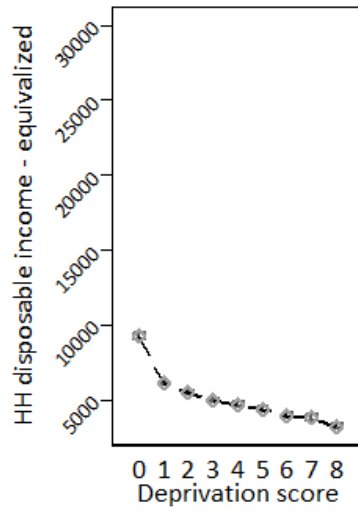
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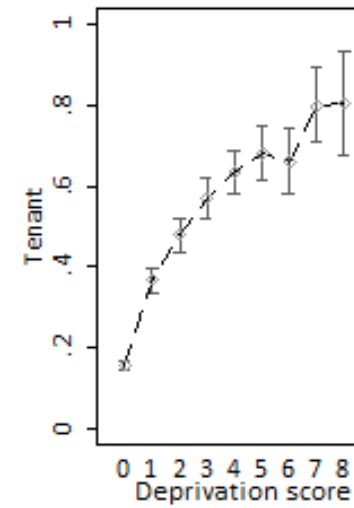
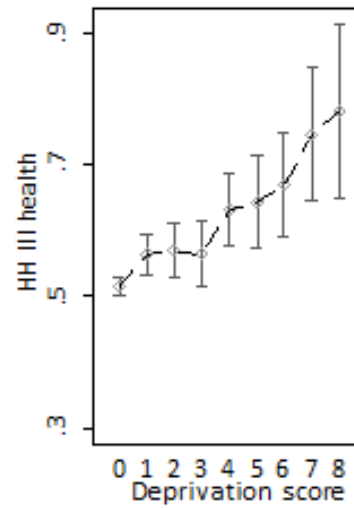
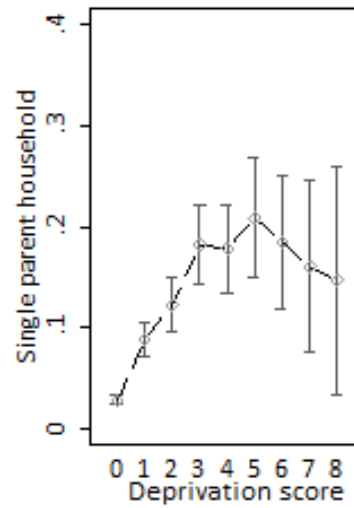
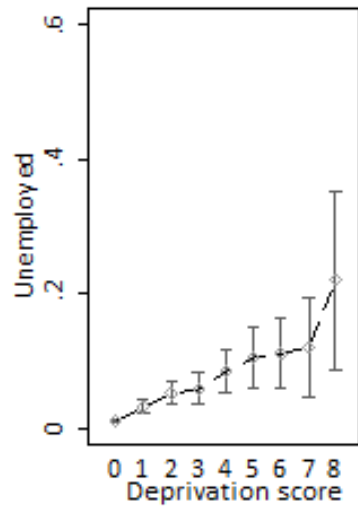
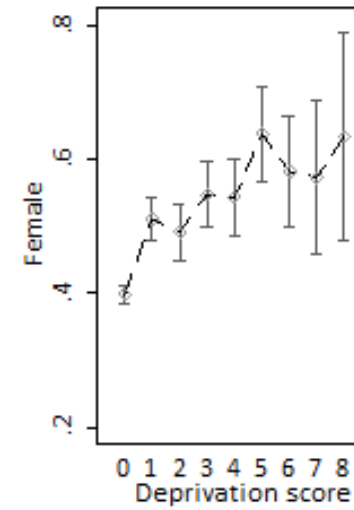
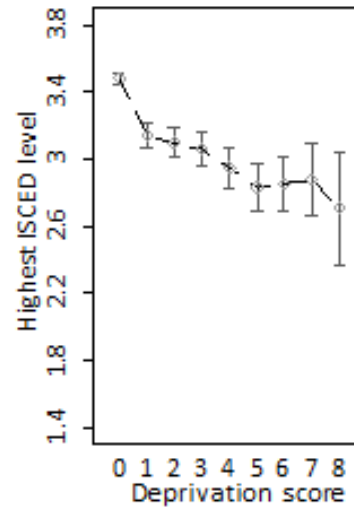
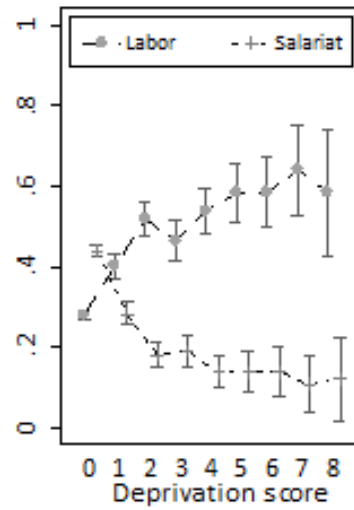
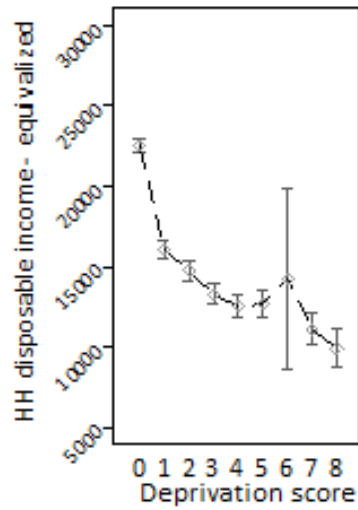
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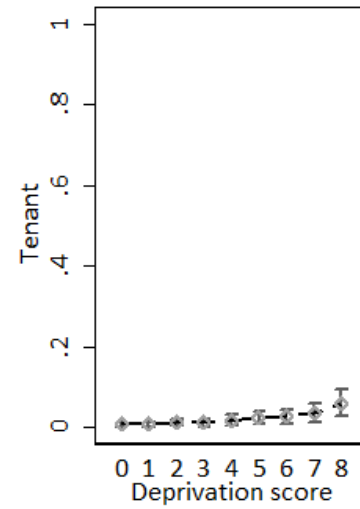
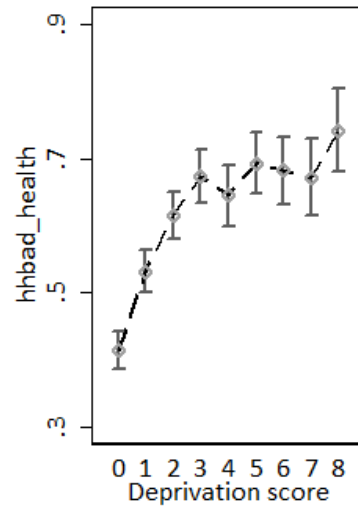
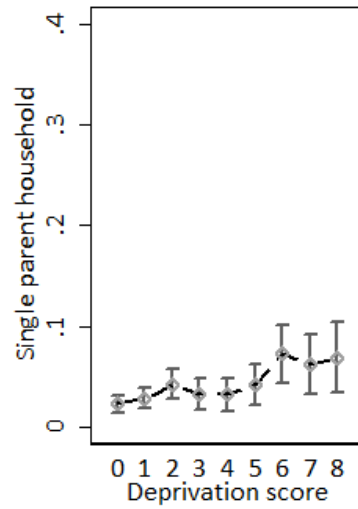
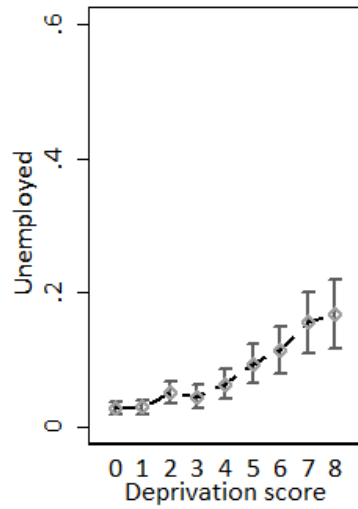
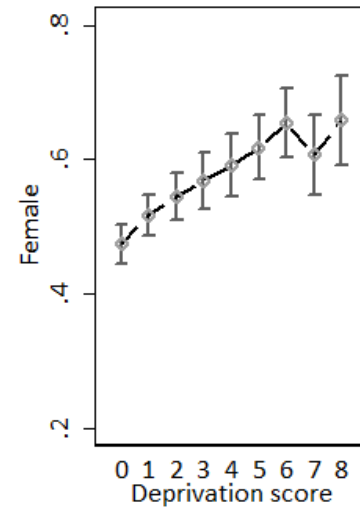
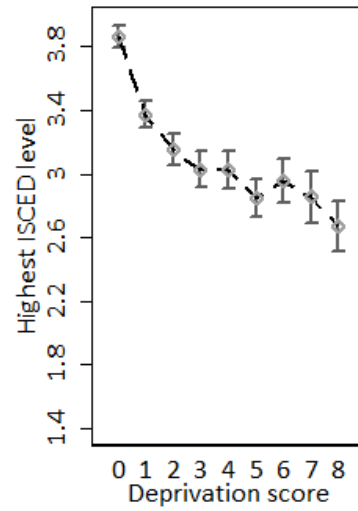
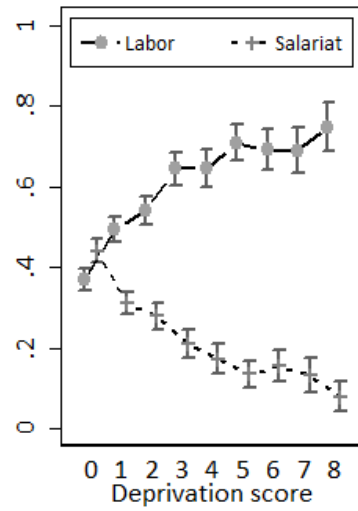
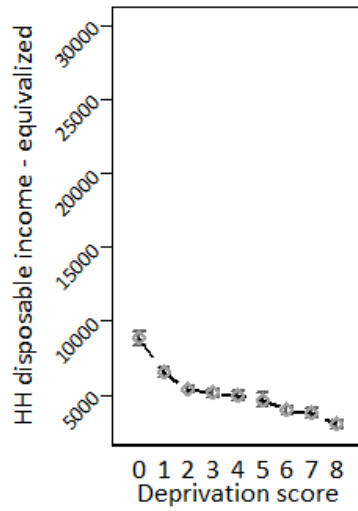
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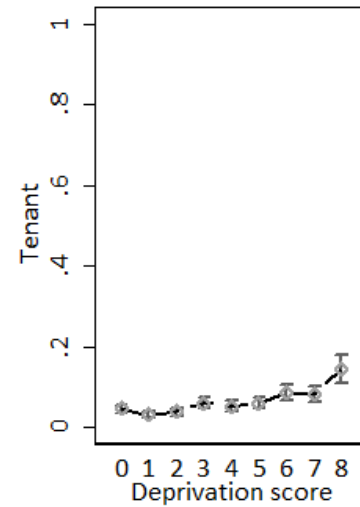
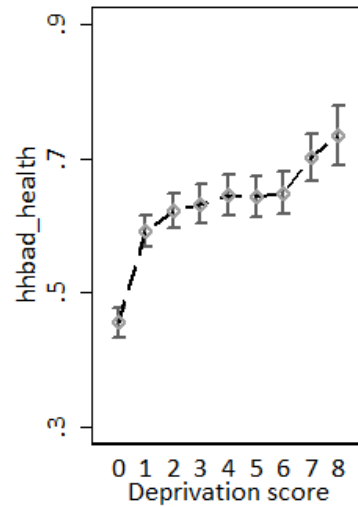
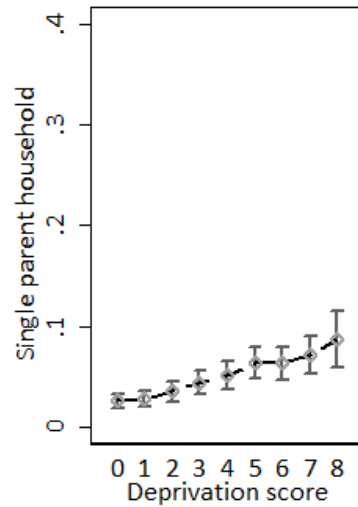
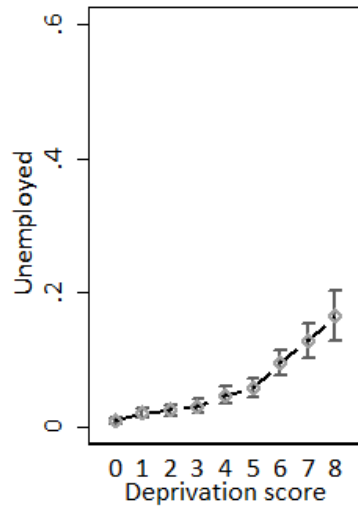
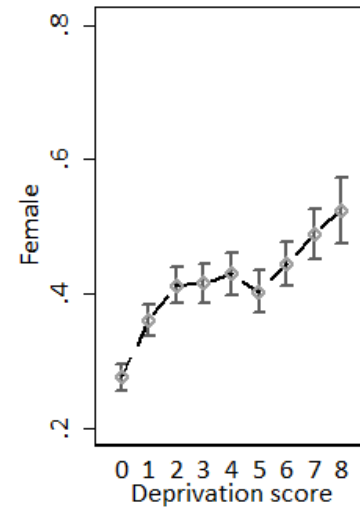
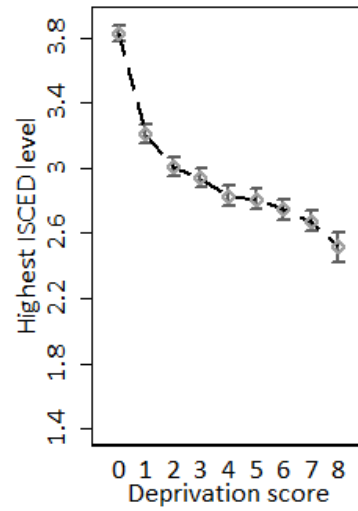
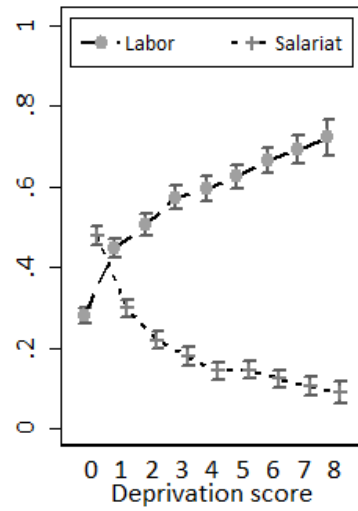
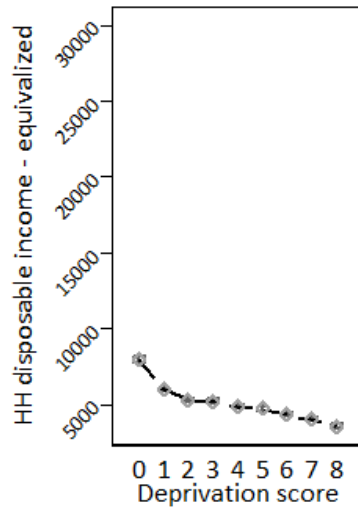
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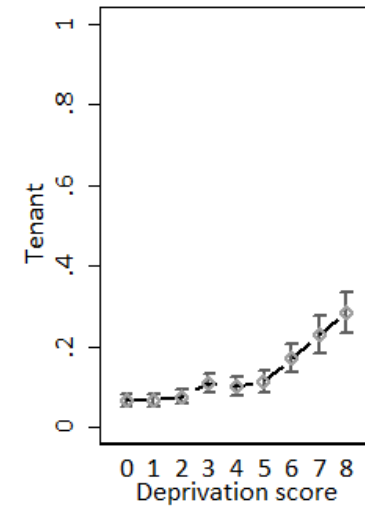
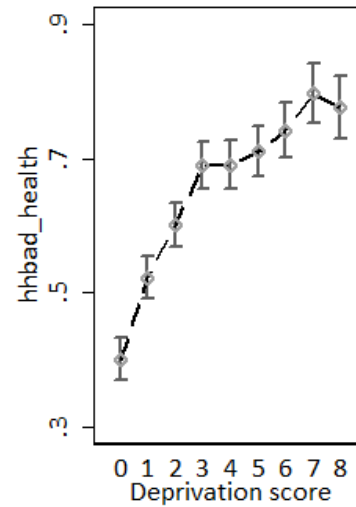
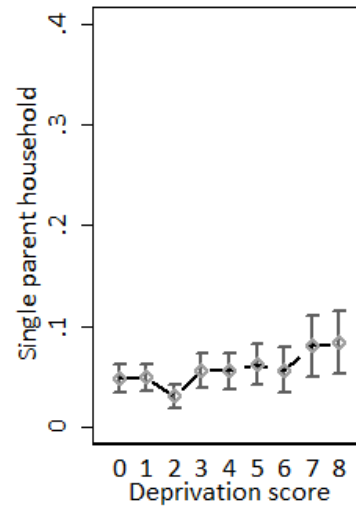
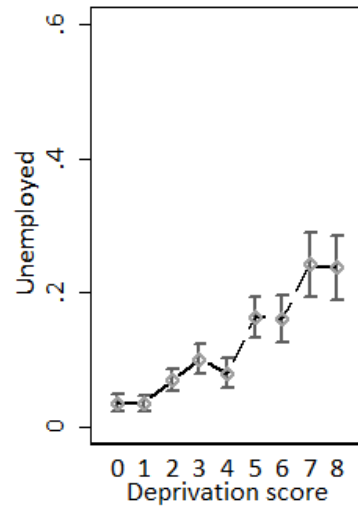
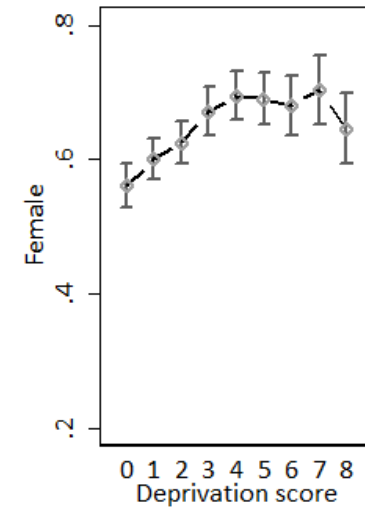
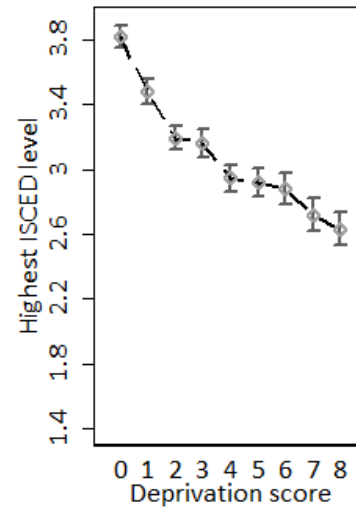
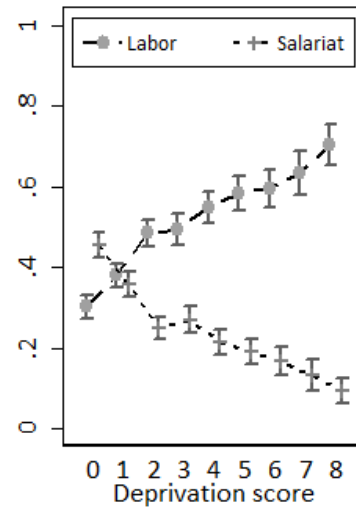
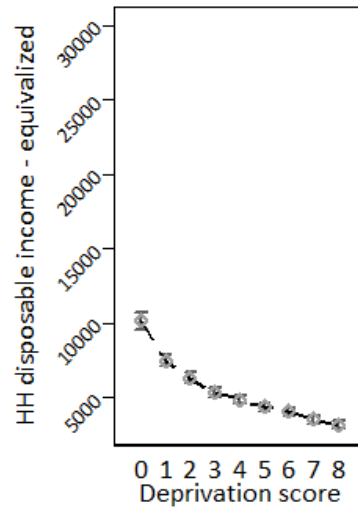
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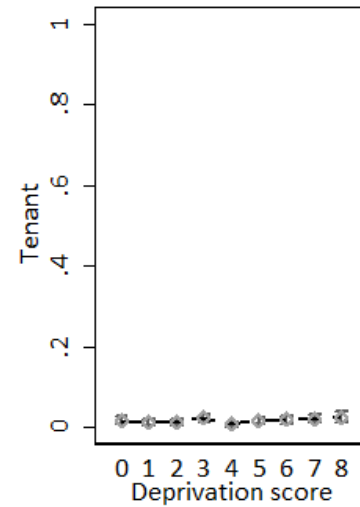
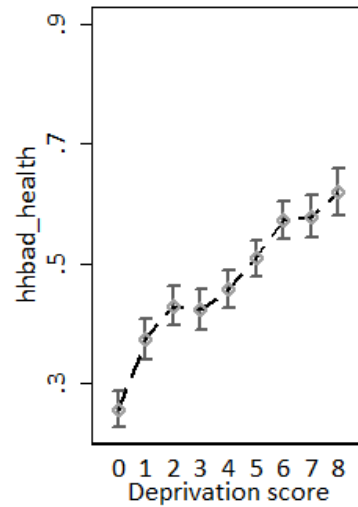
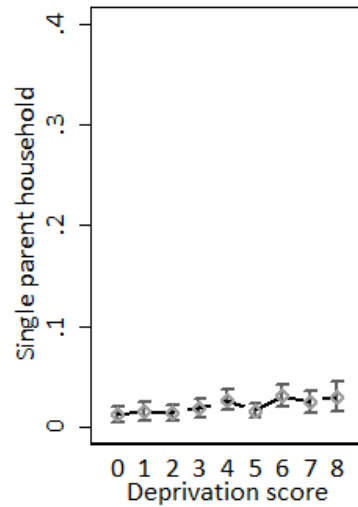
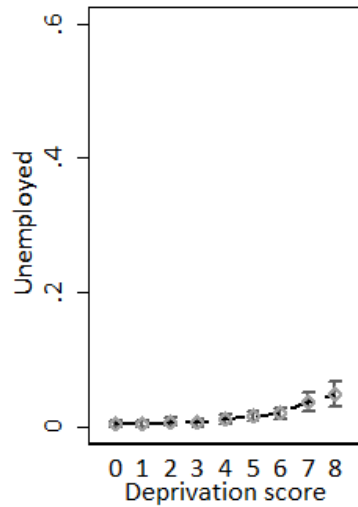
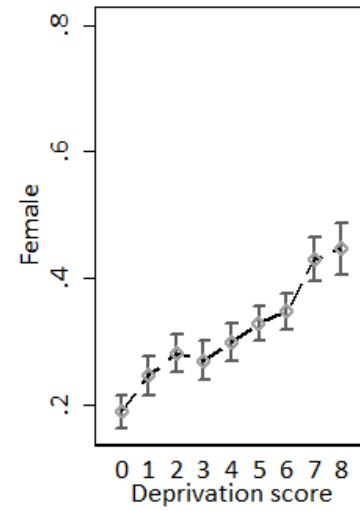
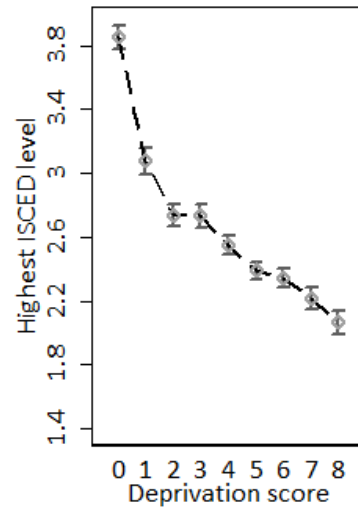
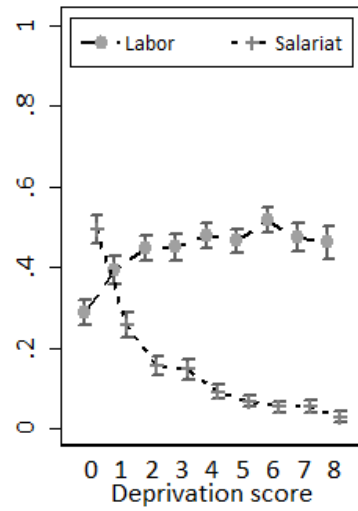
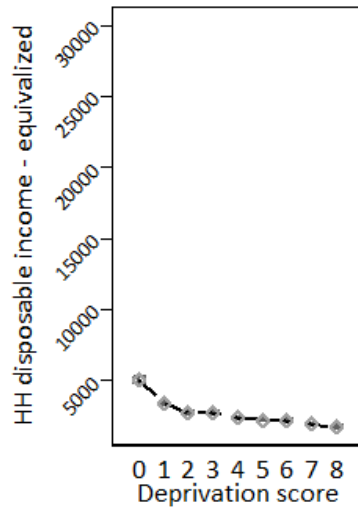
# Hungary



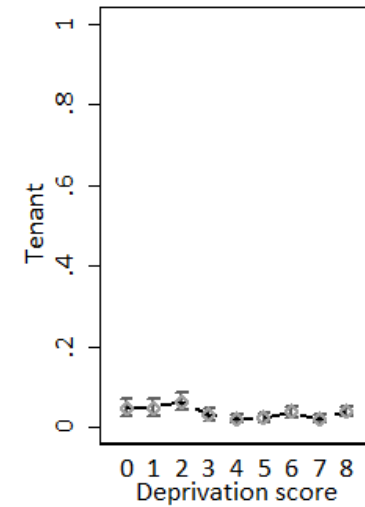
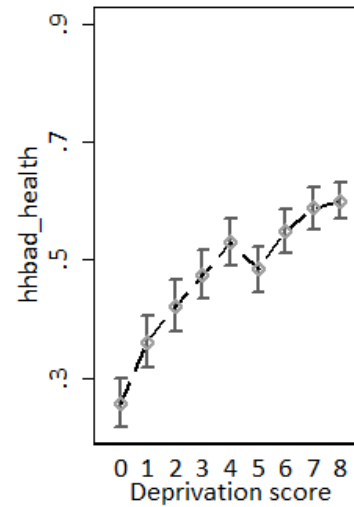
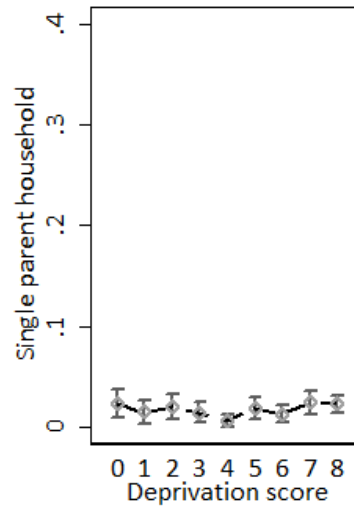
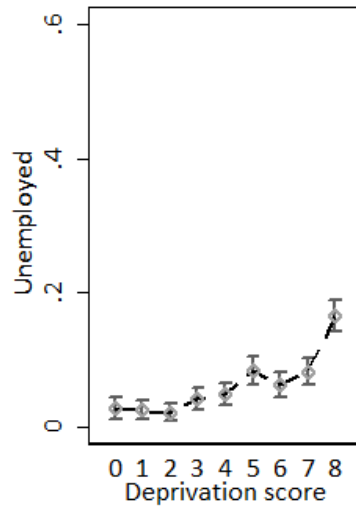
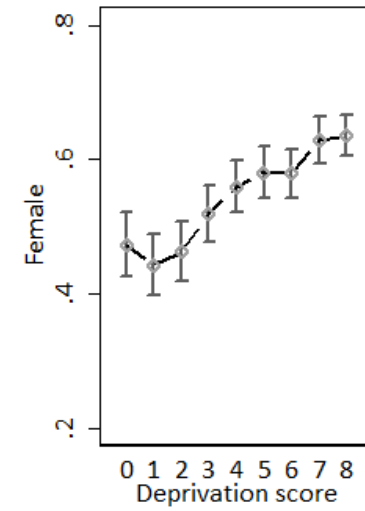
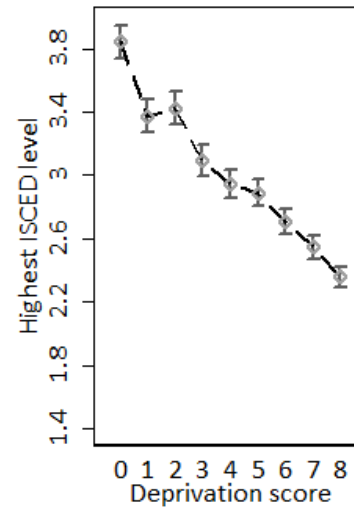
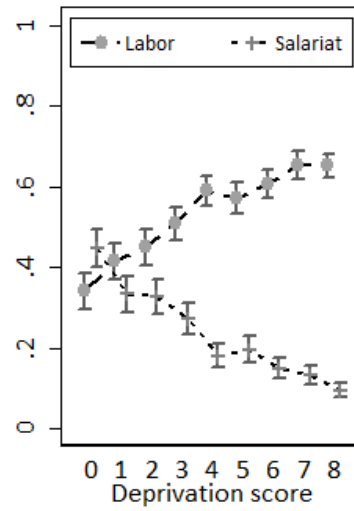
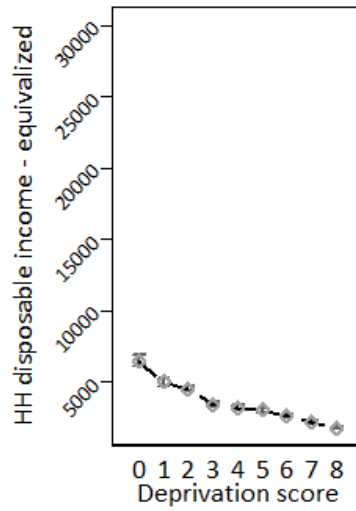
# Latvia



# Romania



# Bulgaria



## **S2: Does weighting or index specification matter?**

The main analysis for testing the distinctiveness of zeros is repeated for two other deprivation indices to test the sensitivity of the results to weighting and index specification. The weighted index is calculated for 9-item WM index using country specific prevalence weights, where the items are multiplied by the prevalence of item deprivation (proportion of people having deprivation for the item) in the reference country. The weighted sum number is rounded to third decimal and multiplied by 100 to reach integer values necessary for applying count models. Therefore, the weighted index scale is between 0 and 100.

The second index is the 13 item adult deprivation index recently proposed by Guio et al. (2016). In addition the items of the WM index, this 13-item index includes having arrears of rent, mortgage or utility bills, ability to face unexpected expenses, having a car and a computer with internet.

The key results are presented below. The conclusions are the same for both cases. For both the weighted and 13 item indices, the best-fit model is the hurdle negative binomial model (HNBM) based on the applied statistical tests as well as AIC and BIC values.

**Table S1: Model selection between PM, NBM and HNBM for the weighted index**

		<b>PM vs NBM</b>	<b>NBM vs. HNBM</b>			<b>HPM vs. HNBM</b>
Country	% of zeros	Alpha ( $\alpha$ ) (sd)	Vuong	Vuong AIC-cor	Vuong BIC-cor	LR test
DENMARK	84.1	19.9 (0.8)	25.6	25	23.3	4625 (pr<0.00)
FINLAND	80.1	15.5 (0.4)	41.7	41.3	40	10819 (pr<0.00)
NETHERLANDS	78.9	13.7 (0.4)	40.5	40.1	38.8	10003 (pr<0.00)
LUXEMBOURG	76.9	10.9 (0.4)	31	30.6	28.9	8926 (pr<0.00)
AUSTRIA	66.8	7.84 (0.2)	43.4	43.4	43.3	14589 (pr<0.00)
UK	65.4	7.78 (0.2)	49.2	48.9	47.5	19701 (pr<0.00)
BELGIUM	63.4	6.62 (0.2)	44.5	44.5	44.4	20232 (pr<0.00)
GERMANY	62.9	6.97 (0.1)	71.1	71.1	71	35484 (pr<0.00)
IRELAND	59.6	5.36 (0.2)	43.9	43.4	41.7	14528 (pr<0.00)
FRANCE	57.6	5.33 (0.1)	69.2	69.8	67.6	34656 (pr<0.00)
ITALY	55.7	5.16 (0.1)	87.5	87.2	86	79009 (pr<0.00)
SPAIN	49.3	3.79 (0.1)	79.5	79.1	77.8	41386 (pr<0.00)
SLOVENIA	49.1	4.07 (0.1)	69.2	68.7	66.9	34664 (pr<0.00)
CZECH REPUBLIC	38.6	2.44 (0.04)	69.9	69.5	67.7	35427 (pr<0.00)
CYPRUS	38.4	2.51 (0.1)	43.8	43.1	40.8	11110 (pr<0.99)
ESTONIA	34.9	2.21 (0.05)	45.3	44.7	42.5	20248 (pr<0.00)
GREECE	34.5	1.80 (0.04)	61.8	61.4	59.8	30135 (pr<0.00)
SLOVAKIA	32.6	2.16 (0.05)	44.7	44.1	42.1	27660 (pr<0.00)
POLAND	28.5	1.88 (0.03)	62.9	62.6	61.2	99837 (pr<0.00)
PORTUGAL	26.3	1.66 (0.04)	40.2	39.8	38.3	38377 (pr<0.00)
LITHUANIA	23.4	1.64 (0.04)	46.4	45.9	44	36098 (pr<0.00)
HUNGARY	18.9	1.34 (0.02)	46.1	45.8	44.5	78779 (pr<0.00)
LATVIA	16.2	1.16 (0.02)	31.1	30.6	28.9	50446 (pr<0.00)
ROMANIA	10.7	0.82 (0.01)	28.9	28.6	27.5	67389 (pr<0.99)
BULGARIA	7.6	0.60 (0.01)	21.3	20.9	19.8	41825 (pr=0.99)

Notes: Table presents the fit statistics results for the weighted index of Whelan and Maitre (2012) for 25 EU countries, comparing multiple count models Alpha is a dispersion parameter. Any value bigger than zero reflect over-dispersion and preference over negative binomial model (NBM), as in  $\alpha=0$  NBM reduces into Poisson model (PM). Vuong test (as well as its bias corrected versions) is a maximum likelihood test for non-nested models used to choose between hurdle vs. standard models. The null hypothesis is equal fit hence numbers higher than 1.96 (and hence significance) shows a preference over hurdle models. In the table, the countries are ordered from highest to lowest based on their rate of zeros. There is significant over-dispersion for all countries and the level of over-dispersion (value of alpha) is closely associated to the level of zeros. Hurdle negative binomial model is the preferred model for all countries. AIC and BIC values also suggest similar conclusions (see next Table).

**Table S2: Model selection for the prevalence weighted index of Whelan and Maitre (2012)**

		PM	NBM	HPM	HNBM	Preferred
DENMARK	AIC	61039	12379	15264	10681	HNBM
	BIC	61178	12525	15503	10925	HNBM
FINLAND	AIC	128858	26968	33449	22861	HNBM
	BIC	129009	27126	33717	23134	HNBM
NETHERLANDS	AIC	112317	26303	32139	22411	HNBM
	BIC	112467	26460	32406	22684	HNBM
LUXEMBOURG	AIC	62197	13325	20059	11226	HNBM
	BIC	62331	13464	20295	11466	HNBM
AUSTRIA	AIC	107112	24477	35625	21176	HNBM
	BIC	107252	24623	35881	21438	HNBM
UK	AIC	144321	33948	48373	29159	HNBM
	BIC	144467	34101	48641	29434	HNBM
BELGIUM	AIC	117405	27963	44098	24220	HNBM
	BIC	117546	28110	44359	24486	HNBM
GERMANY	AIC	262987	60376	86760	51465	HNBM
	BIC	263143	60540	87052	51763	HNBM
IRELAND	AIC	82031	24172	35533	21181	HNBM
	BIC	82168	24315	35789	21442	HNBM
FRANCE	AIC	192985	52577	79726	45724	HNBM
	BIC	193137	52736	80012	46016	HNBM
ITALY	AIC	394190	105702	173363	94826	HNBM
	BIC	394357	105876	173679	95149	HNBM
SPAIN	AIC	222334	73293	106442	65088	HNBM
	BIC	222491	73458	106742	65394	HNBM
SLOVENIA	AIC	182813	53258	82004	47342	HNBM
	BIC	182962	53415	82288	47633	HNBM
CZECH REPUBLIC	AIC	163353	62854	91987	56563	HNBM
	BIC	163504	63012	92279	56861	HNBM
CYPRUS	AIC	56082	21039	29689	18581	HNBM
	BIC	56210	21172	29933	18831	HNBM
ESTONIA	AIC	84757	32464	49926	29680	HNBM
	BIC	84894	32607	50190	29950	HNBM
GREECE	AIC	118372	46873	71466	41865	HNBM
	BIC	118516	47023	71744	42150	HNBM
SLOVAKIA	AIC	101146	36349	60930	33272	HNBM
	BIC	101283	36493	61197	33545	HNBM

POLAND	AIC	286995	96036	188571	88736	HNBM
	BIC	287152	96199	188877	89049	HNBM
PORTUGAL	AIC	109753	38083	73344	35023	HNBM
	BIC	109889	38226	73610	35296	HNBM
LITHUANIA	AIC	122150	41656	74349	38253	HNBM
	BIC	122287	41800	74618	38528	HNBM
HUNGARY	AIC	225325	81193	154516	75739	HNBM
	BIC	225476	81350	154812	76043	HNBM
LATVIA	AIC	131892	48730	96536	46092	HNBM
	BIC	132031	48877	96811	46374	HNBM
ROMANIA	AIC	168030	68958	132632	65245	HNBM
	BIC	168176	69111	132921	65541	HNBM
BULGARIA	AIC	113747	51882	91079	49255	HNBM
	BIC	113886	52028	91355	49538	HNBM

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*Notes: Lower values of information criteria (AIC, BIC) shows better fit. The results show a strong preference for HNBM.*

**Table S3: Model selection between PM, NBM and HNBM for 13 item index of Guio et al. (2016)**

		<b>PM vs NBM</b>	<b>NBM vs. HNBM</b>			<b>HPM vs. HNBM</b>
Country	% of zeros	Alpha (α) (sd)	Vuong	Vuong AIC-cor	Vuong BIC-cor	LR test
DENMARK	84.1	1.6 (0.09)	6.9	5.9	2.1	384 (pr<0.00)
FINLAND	80.1	1.34 (0.05)	12	11.5	9.6	805 (pr<0.00)
NETHERLANDS	78.9	2.67 (0.10)	11.8	11.3	9.6	876 (pr<0.00)
LUXEMBOURG	76.9	1.41 (0.08)	7.4	6.7	4.5	350 (pr<0.00)
AUSTRIA	66.8	1.29 (0.06)	9.7	8.9	6.2	520 (pr<0.00)
UK	65.4	1.19 (0.05)	15.5	14.9	12.9	315 (pr<0.00)
BELGIUM	63.4	1.18 (0.05)	13.2	12.6	10.4	469 (pr<0.00)
GERMANY	62.9	1.23 (0.03)	21.3	20.9	19.3	1279 (pr<0.00)
IRELAND	59.6	0.57 (0.03)	10.7	9.8	7.2	303 (pr<0.00)
FRANCE	57.6	0.98 (0.03)	17.9	17.4	15.5	637 (pr<0.00)
ITALY	55.7	1.01 (0.02)	18.8	18.3	16.4	1784 (pr<0.00)
SPAIN	49.3	0.67 (0.02)	17.6	17.1	15.2	447 (pr<0.00)
SLOVENIA	49.1	0.68 (0.02)	14.9	14.1	11.4	438 (pr<0.00)
CZECH REPUBLIC	38.6	0.37 (0.01)	14	13.3	10.5	246 (pr<0.00)
CYPRUS	38.4	0.24 (0.02)	11.6	10.5	7.3	0.001 (pr>0.95)
ESTONIA	34.9	0.39 (0.02)	8.9	7.6	3.4	236 (pr<0.00)
GREECE	34.5	0.28 (0.01)	15.5	14.9	12.9	149 (pr<0.00)
SLOVAKIA	32.6	0.36 (0.02)	10.6	9.6	6.2	271 (pr<0.00)
POLAND	28.5	0.29 (0.01)	18.3	17.7	15.6	754 (pr<0.00)
PORTUGAL	26.3	0.33 (0.02)	12.1	11.3	9	319 (pr<0.00)
LITHUANIA	23.4	0.34 (0.01)	9.9	8.9	5.6	449 (pr<0.00)
HUNGARY	18.9	0.16 (0.01)	12.9	12.1	9.5	406 (pr<0.00)
LATVIA	16.2	0.12 (0.01)	8.5	7.5	4.2	175 (pr<0.00)
ROMANIA	10.7	0.11 (0.01)	14	13.5	11.5	117 (pr>0.99)
BULGARIA	7.6	0.04 (0.004)	12.5	11.9	9.9	0.001 (pr>0.95)

Notes: Table presents the fit statistic results for the 13 item index of Guio et al. 2016) for 25 EU countries, comparing multiple count models Alpha is a dispersion parameter. Any value bigger than zero reflect over-dispersion and preference over negative binomial model (NBM), as in  $a=0$  NBM reduces into Poisson model (PM). Vuong test (as well as its bias corrected versions) is a maximum likelihood test for non-nested models used to choose between hurdle vs. standard models. The null hypothesis is equal fit hence numbers higher than 1.96 (and hence significance) shows a preference over hurdle models. In the table, the countries are ordered from highest to lowest based on their rate of zeros. There is significant over-dispersion for all countries and the level of over-dispersion (value of alpha) is closely associated to the level of zeros. Hurdle negative binomial model is the preferred model for all countries. AIC and BIC values also suggest similar conclusions (see next Table).

**Table S4: Model selection for the 13 item index of Guio et al. (2016)**

		PM	NBM	HPM	HNBM	Preferred
DENMARK	AIC	11901	10337	10537	10156	HNBM
	BIC	12040	10482	10788	10413	HNBM
FINLAND	AIC	25132	21990	21996	21209	HNBM
	BIC	25283	22148	22276	21495	HNBM
NETHERLANDS	AIC	22947	18256	18277	17412	HNBM
	BIC	23096	18413	18549	17689	HNBM
LUXEMBOURG	AIC	10484	8966	8964	8616	HNBM
	BIC	10617	9105	9206	8863	HNBM
AUSTRIA	AIC	18075	15173	15284	14775	HNBM
	BIC	18215	15319	15544	15042	HNBM
UK	AIC	23305	20379	19708	19420	HNBM
	BIC	23451	20531	19980	19698	HNBM
BELGIUM	AIC	19762	16600	16351	15898	HNBM
	BIC	19902	16748	16614	16167	HNBM
GERMANY	AIC	45842	38187	37615	36351	HNBM
	BIC	45998	38350	37911	36654	HNBM
IRELAND	AIC	16553	15395	15245	14953	HNBM
	BIC	16690	15539	15506	15220	HNBM
FRANCE	AIC	35123	30753	30155	29548	HNBM
	BIC	35275	30912	30443	29843	HNBM
ITALY	AIC	70408	61642	61978	60226	HNBM
	BIC	70575	61816	62296	60551	HNBM
SPAIN	AIC	44507	41114	40364	39919	HNBM
	BIC	44664	41278	40666	40227	HNBM
SLOVENIA	AIC	34290	31270	30933	30497	HNBM
	BIC	34439	31427	31221	30791	HNBM
CZECH REPUBLIC	AIC	36104	34477	34008	33764	HNBM
	BIC	36255	34635	34302	34065	HNBM
CYPRUS	AIC	11372	11125	10703	-	HNBM
	BIC	11499	11258	10957	-	HNBM
ESTONIA	AIC	18864	17828	17815	17581	HNBM
	BIC	19000	17971	18081	17852	HNBM
GREECE	AIC	26728	25513	24756	24612	HNBM
	BIC	26872	25664	25036	24898	HNBM
SLOVAKIA	AIC	21414	20298	20178	19909	HNBM
	BIC	21551	20442	20447	20184	HNBM
POLAND	AIC	55250	52506	51944	51192	HNBM

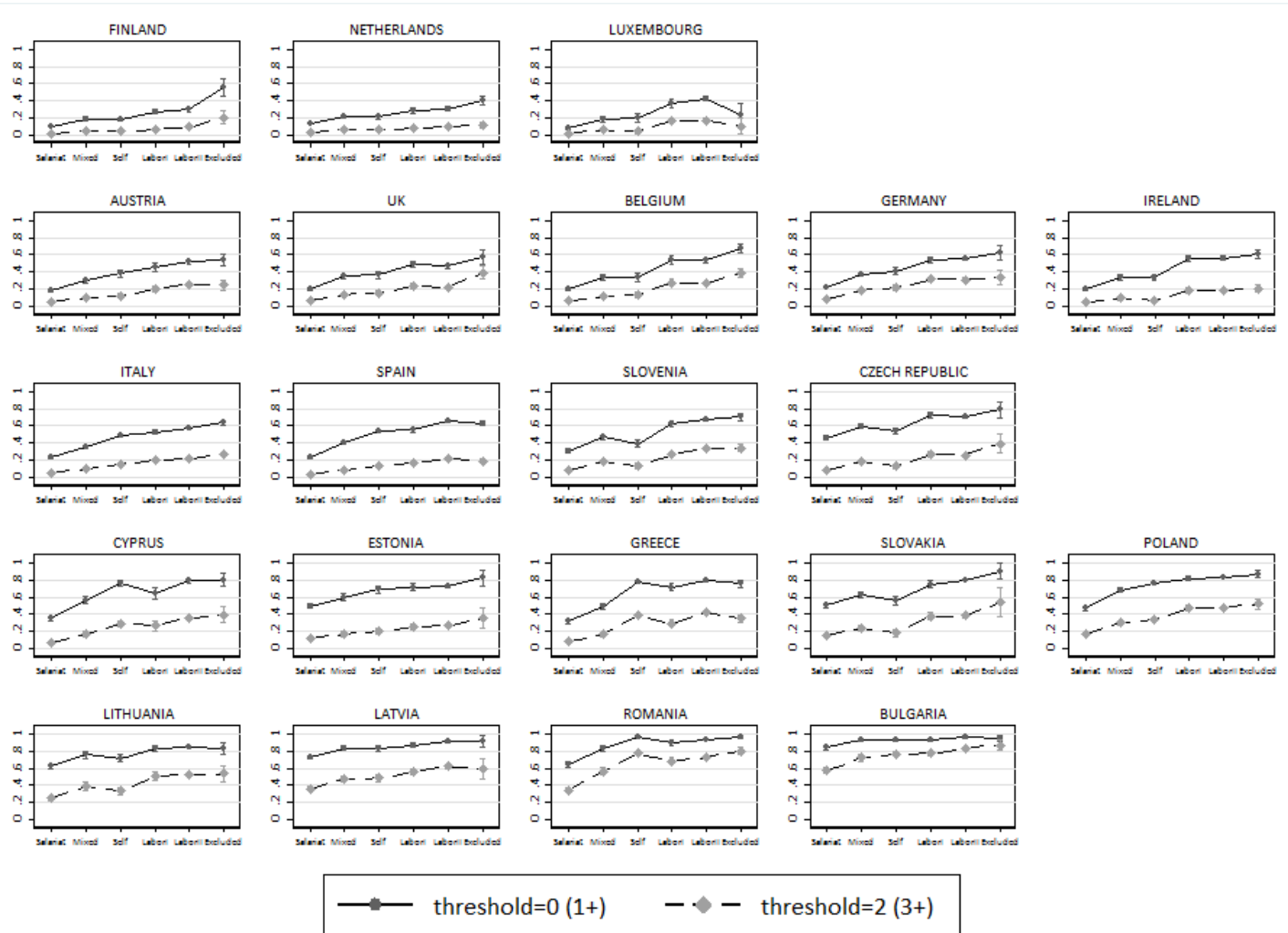
	BIC	55406	52670	52251	51506	HNBM
PORTUGAL	AIC	21290	20100	19838	19522	HNBM
	BIC	21427	20243	20105	19795	HNBM
LITHUANIA	AIC	23649	22209	22294	21848	HNBM
	BIC	23786	22353	22564	22124	HNBM
HUNGARY	AIC	45275	44051	43753	43350	HNBM
	BIC	45426	44208	44052	43655	HNBM
LATVIA	AIC	26449	25966	25818	25644	HNBM
	BIC	26589	26112	26088	25921	HNBM
ROMANIA	AIC	37534	36916	36029	35914	HNBM
	BIC	37680	37069	36320	36212	HNBM
BULGARIA	AIC	27228	27115	26273	26275	OLS
	BIC	27367	27261	26550	26558	OLS

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*Notes: Lower values of information criteria (AIC, BIC) shows better fit. The results show a strong preference for HNBM.*

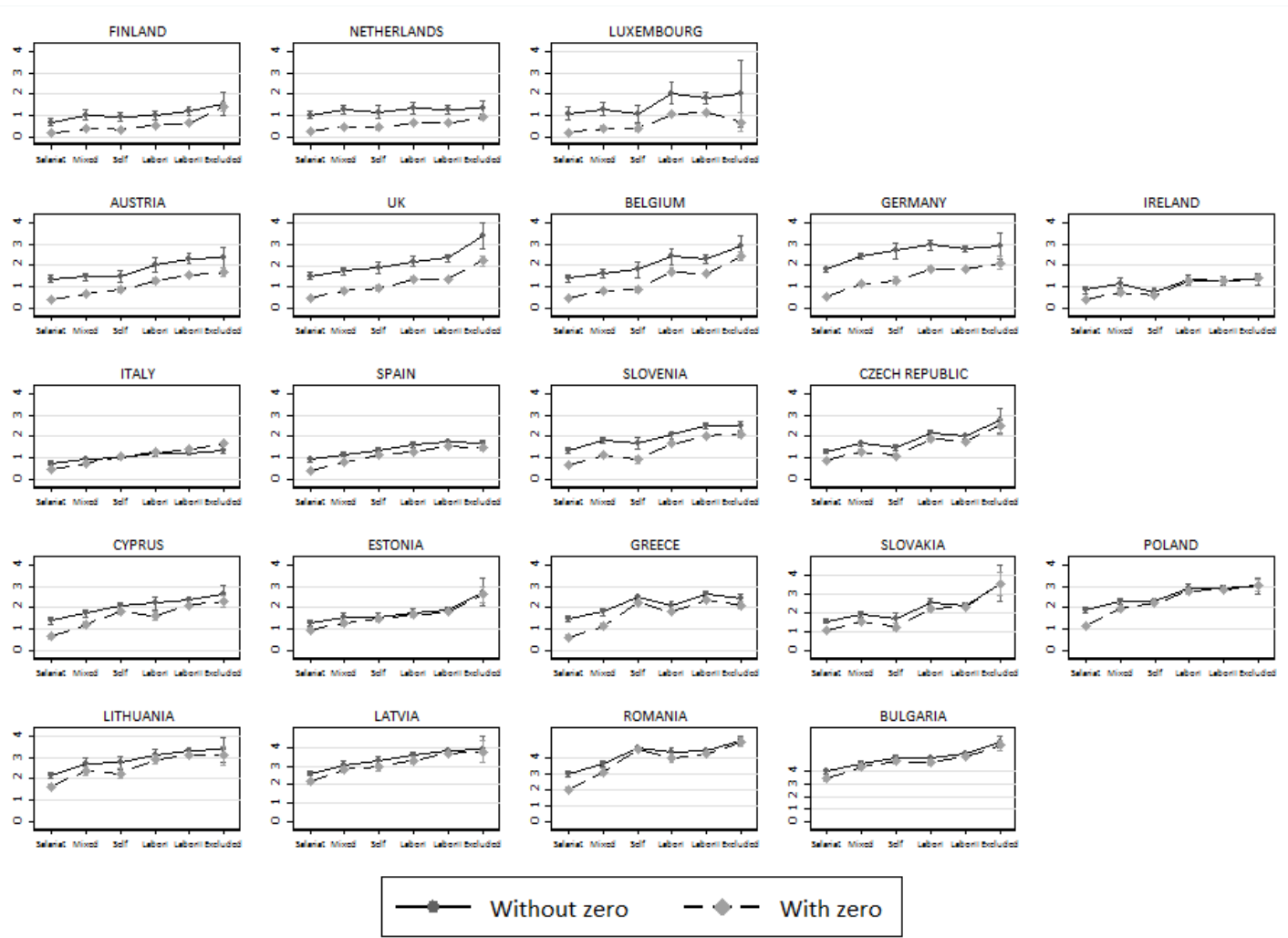
**S3: Social class variation on the risk and the level of deprivation for other 10 countries**

**Figure S1: Social class variation in the risk of deprivation using different thresholds across 10 EU countries**



Notes: The figure shows the average predicted risk of deprivation for social classes across ten countries. The models do not include any control variables. The solid lines show the estimates from models where the threshold for deprivation is two (3+), the dashed lines show the estimates from models where the threshold for deprivation is zero (1+). The figure demonstrates that social gradient in deprivation risk is much clearer when the threshold is zero except for the low group where the social gradient is stronger for the threshold of two mainly due to the fact that when threshold is zero, there is a ceiling effect.

**Figure S2: Social class variation in the level of deprivation across 10 EU countries – with and without zeros**



Notes: The figure shows the average predicted level of deprivation for social classes across ten countries. The models do not include any control variables. The solid lines show the estimates from zero-truncated negative binomial models which do not include zeros into the analysis; the dashed lines show the estimates from OLS models which include zeros into the analysis. The figure demonstrates that social gradient in deprivation level is inflated when the zero is included into the analysis.

**S4: The determinants of risk and level of deprivation for 25 EU countries – comparing conventional and hurdle models; full results**

	DENMARK				FINLAND			
	Hurdle NBM Risk b/se	Level b/se	Conventional Risk b/se	Level b/se	Hurdle NBM Risk b/se	Level b/se	Conventional Risk b/se	Level b/se
<b>HRP Social Class (ref=Salariat)</b>								
Mixed	0.02 (0.01)	0.16 (0.13)	0.01 (0.01)	0.04 (0.03)	0.03* (0.01)	0.21* (0.10)	0.02* (0.01)	0.02 (0.03)
Small self-emp.	0.03 (0.02)	-0.00 (0.19)	0.01 (0.01)	0.05 (0.05)	0.03* (0.01)	0.15 (0.10)	0.02* (0.01)	0.04 (0.03)
Labor non-manual	0.04** (0.02)	0.06 (0.13)	0.02* (0.01)	0.07 (0.04)	0.05*** (0.01)	0.12 (0.09)	0.02*** (0.01)	0.08* (0.03)
Labor manual	0.08*** (0.02)	0.01 (0.12)	0.02** (0.01)	0.11** (0.04)	0.08*** (0.01)	0.21* (0.09)	0.03*** (0.01)	0.16*** (0.03)
Excluded	0.15*** (0.03)	0.07 (0.17)	0.04** (0.02)	0.48*** (0.07)	0.09** (0.04)	0.49* (0.20)	0.04** (0.02)	0.57*** (0.09)
<b>HRP Education (ref=Tertiary)</b>								
Upper secondary	-0.00 (0.01)	0.03 (0.10)	0.00 (0.01)	-0.01 (0.03)	0.03** (0.01)	0.11 (0.08)	0.01 (0.01)	0.02 (0.03)
Lower secondary ≥	0.00 (0.01)	0.13 (0.12)	0.01 (0.01)	0.05 (0.04)	0.04** (0.01)	0.24** (0.09)	0.02** (0.01)	0.09** (0.03)
HRP Divorced	0.07*** (0.02)	0.08 (0.11)	0.02 (0.01)	0.18*** (0.04)	0.03** (0.01)	0.04 (0.07)	0.01* (0.01)	0.11*** (0.03)
HRP Single parent	0.15*** (0.03)	0.40* (0.18)	0.07*** (0.02)	0.58*** (0.06)	0.09*** (0.02)	0.17 (0.11)	0.04** (0.01)	0.28*** (0.05)
HH 3+ children	0.04 (0.02)	0.14 (0.20)	0.01 (0.02)	0.10 (0.06)	0.04* (0.02)	0.20 (0.15)	0.02 (0.01)	0.09* (0.04)
HRP Female	0.04*** (0.01)	-0.04 (0.09)	0.01 (0.01)	0.06* (0.02)	0.04*** (0.01)	0.13* (0.06)	0.02*** (0.00)	0.10*** (0.02)
HH Income (log equ.)	-0.11*** (0.01)	-0.31** (0.11)	-0.02*** (0.00)	-0.24*** (0.03)	-0.16*** (0.01)	-0.28*** (0.05)	-0.05*** (0.00)	-0.35*** (0.02)
HH Unemployed	0.19*** (0.04)	0.27 (0.16)	0.07*** (0.02)	0.71*** (0.07)	0.14*** (0.02)	0.47*** (0.10)	0.08*** (0.01)	0.77*** (0.04)
HH Chronic ill-health	0.04** (0.01)	0.16 (0.10)	0.01* (0.01)	0.10** (0.03)	0.03*** (0.01)	0.14* (0.07)	0.01** (0.01)	0.09*** (0.02)
HH Disability	0.06*** (0.01)	0.15 (0.10)	0.02** (0.01)	0.18*** (0.03)	0.06*** (0.01)	0.30*** (0.07)	0.03*** (0.01)	0.21*** (0.02)
HH Tenant	0.09*** (0.01)	0.26** (0.09)	0.04*** (0.01)	0.27*** (0.03)	0.11*** (0.01)	0.29*** (0.06)	0.05*** (0.01)	0.39*** (0.03)
N	5493	5493	5493	5493	9744	9744	9744	9744

	NETHERLANDS				LUXEMBOURG			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salaried)								
Mixed	0.01 (0.01)	-0.01 (0.08)	-0.00 (0.01)	-0.01 (0.03)	0.02 (0.02)	0.05 (0.16)	0.03* (0.01)	-0.09 (0.06)
Small self-emp.	0.02 (0.02)	-0.08 (0.11)	-0.00 (0.01)	0.04 (0.04)	0.03 (0.03)	-0.14 (0.20)	-0.01 (0.01)	-0.05 (0.08)
Labor non-manual	0.00 (0.01)	-0.03 (0.10)	-0.01 (0.01)	-0.01 (0.04)	0.05* (0.02)	0.32 (0.19)	0.05** (0.01)	0.21** (0.08)
Labor manual	0.06*** (0.01)	0.00 (0.08)	0.01 (0.01)	0.09** (0.03)	0.09*** (0.02)	0.25 (0.15)	0.06*** (0.01)	0.31*** (0.06)
Excluded	0.04 (0.02)	-0.08 (0.10)	-0.01 (0.01)	0.14* (0.05)	0.04 (0.06)	0.24 (0.45)	0.05 (0.04)	0.15 (0.20)
HRP Education (ref=Tertiary)								
Upper secondary	0.04*** (0.01)	0.13 (0.08)	0.01* (0.01)	0.05 (0.03)	0.05** (0.02)	0.08 (0.16)	0.02 (0.01)	0.02 (0.05)
Lower secondary ≥	0.06*** (0.01)	0.27** (0.09)	0.04*** (0.01)	0.18*** (0.03)	0.05** (0.02)	0.10 (0.16)	0.01 (0.01)	0.05 (0.06)
HRP Divorced	0.07*** (0.01)	0.26*** (0.08)	0.03*** (0.01)	0.33*** (0.04)	0.08*** (0.02)	0.17 (0.11)	0.04*** (0.01)	0.33*** (0.06)
HRP Single parent	0.11*** (0.02)	0.13 (0.10)	0.04*** (0.01)	0.48*** (0.06)	0.06* (0.03)	0.18 (0.14)	0.02 (0.01)	0.58*** (0.09)
HH 3+ children	0.02 (0.02)	0.04 (0.13)	0.01 (0.01)	0.06 (0.05)	0.01 (0.02)	0.01 (0.15)	0.01 (0.01)	0.05 (0.08)
HRP Female	0.05*** (0.01)	0.09 (0.06)	0.02** (0.01)	0.13*** (0.02)	0.03** (0.01)	0.20* (0.10)	0.02* (0.01)	0.12** (0.04)
HH Income (log equ.)	-0.19*** (0.01)	-0.52*** (0.08)	-0.06*** (0.01)	-0.43*** (0.03)	-0.25*** (0.01)	-0.68*** (0.11)	-0.12*** (0.01)	-0.67*** (0.04)
HH Unemployed	0.20*** (0.05)	0.34 (0.18)	0.08** (0.03)	0.90*** (0.10)	0.12*** (0.03)	0.15 (0.13)	0.04* (0.01)	0.88*** (0.10)
HH Chronic ill-health	0.04*** (0.01)	0.12 (0.07)	0.02** (0.01)	0.13*** (0.03)	0.05*** (0.01)	0.08 (0.10)	0.02* (0.01)	0.14** (0.04)
HH Disability	0.07*** (0.01)	0.37*** (0.07)	0.04*** (0.01)	0.29*** (0.03)	0.06*** (0.01)	0.40*** (0.11)	0.04*** (0.01)	0.28*** (0.04)
HH Tenant	0.12*** (0.01)	0.41*** (0.07)	0.06*** (0.01)	0.45*** (0.03)	0.08*** (0.01)	0.44*** (0.10)	0.06*** (0.01)	0.46*** (0.04)
N	9242	9242	9242	9242	4185	4185	4185	4185

	AUSTRIA				UK			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salaried)								
Mixed	0.05** (0.02)	0.02 (0.11)	0.01 (0.01)	0.02 (0.05)	0.04** (0.01)	0.01 (0.10)	0.02 (0.01)	0.02 (0.05)
Small self-emp.	0.09*** (0.02)	0.16 (0.15)	0.04* (0.02)	0.15* (0.08)	0.05* (0.02)	0.05 (0.13)	0.03* (0.02)	0.07 (0.07)
Labor non-manual	0.09*** (0.02)	0.21 (0.14)	0.04** (0.01)	0.24** (0.08)	0.05** (0.02)	0.12 (0.11)	0.03* (0.01)	0.14* (0.06)
Labor manual	0.13*** (0.02)	0.48*** (0.12)	0.08*** (0.01)	0.50*** (0.06)	0.08*** (0.02)	0.35** (0.11)	0.05*** (0.01)	0.29*** (0.05)
Excluded	0.05 (0.03)	0.35 (0.18)	0.03 (0.02)	0.31** (0.11)	0.03 (0.04)	0.71*** (0.21)	0.07** (0.03)	0.63*** (0.12)
HRP Education (ref=Tertiary)								
Upper secondary	0.04** (0.02)	0.09 (0.12)	0.03* (0.01)	0.03 (0.05)	0.05*** (0.01)	0.10 (0.10)	0.03*** (0.01)	0.10* (0.04)
Lower secondary ≥	0.10*** (0.02)	0.32* (0.14)	0.07*** (0.01)	0.41*** (0.07)	0.07*** (0.02)	0.26* (0.11)	0.05*** (0.01)	0.21*** (0.05)
HRP Divorced	0.08*** (0.02)	0.44*** (0.10)	0.06*** (0.01)	0.43*** (0.05)	0.08*** (0.01)	0.28*** (0.08)	0.05*** (0.01)	0.34*** (0.05)
HRP Single parent	0.11*** (0.03)	0.24 (0.15)	0.06** (0.02)	0.45*** (0.09)	0.11*** (0.02)	0.09 (0.10)	0.05*** (0.01)	0.49*** (0.07)
HH 3+ children	0.08* (0.03)	0.23 (0.20)	0.08** (0.03)	0.29** (0.11)	0.08* (0.03)	-0.01 (0.13)	0.02 (0.02)	0.20* (0.09)
HRP Female	0.03** (0.01)	0.24** (0.08)	0.03*** (0.01)	0.14*** (0.04)	0.05*** (0.01)	0.18* (0.07)	0.03*** (0.01)	0.15*** (0.04)
HH Income (log equ.)	-0.28*** (0.01)	-0.55*** (0.07)	-0.13*** (0.01)	-0.81*** (0.04)	-0.16*** (0.01)	-0.40*** (0.06)	-0.09*** (0.01)	-0.48*** (0.03)
HH Unemployed	0.23*** (0.03)	0.59*** (0.15)	0.14*** (0.02)	1.21*** (0.10)	0.14*** (0.04)	0.62*** (0.16)	0.10*** (0.02)	1.13*** (0.11)
HH Chronic ill-health	0.06*** (0.01)	0.09 (0.10)	0.03* (0.01)	0.18*** (0.05)	0.01 (0.01)	0.09 (0.10)	0.01 (0.01)	0.08 (0.05)
HH Disability	0.09*** (0.01)	0.39*** (0.10)	0.07*** (0.01)	0.33*** (0.05)	0.10*** (0.01)	0.39*** (0.10)	0.07*** (0.01)	0.42*** (0.05)
HH Tenant	0.08*** (0.01)	0.60*** (0.08)	0.08*** (0.01)	0.44*** (0.04)	0.22*** (0.01)	0.57*** (0.07)	0.14*** (0.01)	0.90*** (0.04)
N	5703	5703	5703	5703	7572	7572	7572	7572

	BELGIUM				GERMANY			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarial)								
Mixed	0.04* (0.02)	-0.04 (0.12)	0.00 (0.01)	-0.01 (0.06)	0.03** (0.01)	0.23** (0.07)	0.03*** (0.01)	0.08* (0.04)
Small self-emp.	0.01 (0.02)	0.19 (0.17)	0.02 (0.02)	0.04 (0.08)	0.05* (0.02)	0.42** (0.14)	0.05** (0.02)	0.31*** (0.07)
Labor non-manual	0.07** (0.02)	0.20 (0.15)	0.03 (0.02)	0.27** (0.09)	0.07*** (0.02)	0.32*** (0.09)	0.05*** (0.01)	0.32*** (0.06)
Labor manual	0.09*** (0.02)	0.28* (0.12)	0.06*** (0.01)	0.32*** (0.06)	0.11*** (0.01)	0.44*** (0.08)	0.08*** (0.01)	0.44*** (0.04)
Excluded	0.09** (0.03)	0.38* (0.16)	0.06** (0.02)	0.70*** (0.10)	-0.02 (0.04)	0.11 (0.19)	-0.00 (0.02)	0.05 (0.15)
HRP Education (ref=Tertiary)								
Upper secondary	0.05*** (0.02)	0.10 (0.11)	0.03** (0.01)	0.02 (0.05)	0.03*** (0.01)	0.15* (0.06)	0.03*** (0.01)	0.07* (0.03)
Lower secondary ≥	0.11*** (0.02)	0.46*** (0.12)	0.08*** (0.01)	0.41*** (0.06)	0.09*** (0.02)	0.45*** (0.09)	0.07*** (0.01)	0.54*** (0.06)
HRP Divorced	0.11*** (0.02)	0.26** (0.09)	0.06*** (0.01)	0.42*** (0.06)	0.09*** (0.01)	0.42*** (0.07)	0.07*** (0.01)	0.55*** (0.04)
HRP Single parent	0.07** (0.03)	0.03 (0.11)	0.01 (0.02)	0.31*** (0.09)	0.07*** (0.02)	0.19* (0.09)	0.06*** (0.01)	0.45*** (0.07)
HH 3+ children	0.05 (0.03)	-0.06 (0.16)	0.01 (0.02)	0.13 (0.10)	0.09** (0.03)	0.32 (0.17)	0.08*** (0.02)	0.41*** (0.10)
HRP Female	0.09*** (0.01)	0.38*** (0.08)	0.07*** (0.01)	0.33*** (0.05)	0.04*** (0.01)	0.22*** (0.06)	0.03*** (0.01)	0.19*** (0.03)
HH Income (log equ.)	-0.26*** (0.01)	-0.60*** (0.08)	-0.14*** (0.01)	-0.80*** (0.04)	-0.31*** (0.01)	-0.67*** (0.05)	-0.17*** (0.01)	-1.00*** (0.03)
HH Unemployed	0.13*** (0.03)	0.43*** (0.12)	0.09*** (0.02)	0.85*** (0.08)	0.23*** (0.02)	0.78*** (0.09)	0.18*** (0.02)	1.77*** (0.06)
HH Chronic ill-health	0.07*** (0.01)	0.05 (0.10)	0.03** (0.01)	0.20*** (0.05)	0.03*** (0.01)	0.19** (0.06)	0.03*** (0.01)	0.16*** (0.03)
HH Disability	0.06*** (0.02)	0.29** (0.11)	0.04*** (0.01)	0.29*** (0.06)	0.09*** (0.01)	0.32*** (0.06)	0.07*** (0.01)	0.40*** (0.03)
HH Tenant	0.13*** (0.01)	0.62*** (0.08)	0.11*** (0.01)	0.73*** (0.05)	0.06*** (0.01)	0.33*** (0.06)	0.05*** (0.01)	0.30*** (0.03)
N	6007	6007	6007	6007	12502	12502	12502	12502

	IRELAND				FRANCE			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salaried)								
Mixed	0.05* (0.02)	0.18 (0.13)	0.03* (0.02)	0.10 (0.06)	0.05*** (0.01)	0.07 (0.08)	0.02* (0.01)	0.06 (0.04)
Small self-emp.	0.05* (0.02)	-0.14 (0.12)	0.00 (0.01)	0.00 (0.06)	0.04* (0.02)	0.23* (0.11)	0.01 (0.01)	0.19*** (0.06)
Labor non-manual	0.12*** (0.02)	0.17 (0.11)	0.05*** (0.01)	0.30*** (0.06)	0.06** (0.02)	-0.00 (0.10)	0.01 (0.01)	0.15* (0.07)
Labor manual	0.15*** (0.02)	0.16 (0.10)	0.06*** (0.01)	0.31*** (0.06)	0.09*** (0.01)	0.17* (0.08)	0.05*** (0.01)	0.30*** (0.05)
Excluded	0.14*** (0.03)	0.26 (0.14)	0.08*** (0.02)	0.43*** (0.08)	0.08* (0.04)	-0.02 (0.14)	-0.02 (0.02)	0.37** (0.12)
HRP Education (ref=Tertiary)								
Upper secondary	0.01 (0.02)	0.03 (0.10)	0.01 (0.01)	0.04 (0.05)	0.07*** (0.01)	0.13 (0.08)	0.04*** (0.01)	0.09* (0.04)
Lower secondary ≥	0.12*** (0.02)	0.10 (0.10)	0.04** (0.01)	0.26*** (0.05)	0.11*** (0.02)	0.29*** (0.09)	0.08*** (0.01)	0.37*** (0.05)
HRP Divorced	0.12*** (0.02)	0.11 (0.09)	0.04** (0.01)	0.31*** (0.07)	0.08*** (0.01)	0.32*** (0.07)	0.06*** (0.01)	0.41*** (0.05)
HRP Single parent	0.19*** (0.03)	0.19 (0.11)	0.07*** (0.02)	0.62*** (0.08)	0.04* (0.02)	0.20* (0.09)	0.04** (0.01)	0.44*** (0.07)
HH 3+ children	0.08** (0.03)	0.08 (0.11)	0.04* (0.02)	0.23** (0.07)	0.05* (0.02)	0.21 (0.12)	0.05** (0.02)	0.27*** (0.07)
HRP Female	0.04** (0.01)	-0.02 (0.07)	0.00 (0.01)	0.05 (0.04)	0.08*** (0.01)	0.49*** (0.06)	0.08*** (0.01)	0.41*** (0.03)
HH Income (log equ.)	-0.18*** (0.01)	-0.28*** (0.06)	-0.06*** (0.01)	-0.38*** (0.03)	-0.32*** (0.01)	-0.85*** (0.06)	-0.18*** (0.01)	-0.92*** (0.03)
HH Unemployed	0.25*** (0.03)	0.28** (0.10)	0.10*** (0.02)	0.73*** (0.07)	0.22*** (0.03)	0.62*** (0.11)	0.14*** (0.02)	1.35*** (0.08)
HH Chronic ill-health	0.06*** (0.02)	0.19* (0.09)	0.04** (0.01)	0.22*** (0.05)	0.04*** (0.01)	0.10 (0.06)	0.02* (0.01)	0.14*** (0.04)
HH Disability	0.10*** (0.02)	0.30** (0.09)	0.05*** (0.01)	0.33*** (0.05)	0.08*** (0.01)	0.42*** (0.07)	0.07*** (0.01)	0.39*** (0.04)
HH Tenant	0.15*** (0.02)	0.61*** (0.08)	0.11*** (0.01)	0.80*** (0.05)	0.11*** (0.01)	0.53*** (0.06)	0.09*** (0.01)	0.62*** (0.04)
N	5070	5070	5070	5070	10214	10214	10214	10214

	ITALY				SPAIN			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarial)								
Mixed	0.03** (0.01)	0.12 (0.06)	0.02** (0.01)	0.02 (0.03)	0.06*** (0.01)	0.14 (0.08)	0.03** (0.01)	0.05 (0.04)
Small self-emp.	0.06*** (0.01)	0.11 (0.06)	0.04*** (0.01)	0.11** (0.03)	0.05** (0.02)	0.16* (0.08)	0.04*** (0.01)	0.04 (0.05)
Labor non-manual	0.09*** (0.01)	0.24** (0.07)	0.06*** (0.01)	0.22*** (0.05)	0.10*** (0.02)	0.36*** (0.08)	0.07*** (0.01)	0.23*** (0.05)
Labor manual	0.10*** (0.01)	0.27*** (0.05)	0.07*** (0.01)	0.29*** (0.03)	0.16*** (0.01)	0.47*** (0.07)	0.10*** (0.01)	0.43*** (0.04)
Excluded	0.11*** (0.01)	0.32*** (0.07)	0.08*** (0.01)	0.40*** (0.05)	0.10*** (0.02)	0.34*** (0.09)	0.06*** (0.01)	0.27*** (0.06)
HRP Education (ref=Tertiary)								
Upper secondary	0.07*** (0.01)	0.04 (0.08)	0.03*** (0.01)	0.01 (0.04)	0.08*** (0.01)	0.07 (0.07)	0.02* (0.01)	0.09* (0.04)
Lower secondary ≥	0.16*** (0.01)	0.15 (0.08)	0.08*** (0.01)	0.27*** (0.04)	0.18*** (0.01)	0.27*** (0.06)	0.07*** (0.01)	0.41*** (0.04)
HRP Divorced	0.05*** (0.01)	0.18* (0.07)	0.04*** (0.01)	0.21*** (0.04)	0.11*** (0.02)	0.28*** (0.07)	0.06*** (0.01)	0.39*** (0.05)
HRP Single parent	-0.01 (0.02)	0.12 (0.09)	0.02 (0.01)	0.05 (0.06)	0.06* (0.03)	0.08 (0.11)	0.03 (0.02)	0.19* (0.08)
HH 3+ children	0.08** (0.02)	0.23 (0.12)	0.05** (0.02)	0.33*** (0.07)	0.04 (0.03)	0.44*** (0.13)	0.05* (0.02)	0.50*** (0.08)
HRP Female	0.04*** (0.01)	0.11** (0.04)	0.03*** (0.01)	0.13*** (0.02)	0.05*** (0.01)	0.13*** (0.04)	0.03*** (0.01)	0.17*** (0.03)
HH Income (log equ.)	-0.23*** (0.01)	-0.43*** (0.03)	-0.10*** (0.00)	-0.66*** (0.02)	-0.18*** (0.01)	-0.32*** (0.03)	-0.06*** (0.00)	-0.49*** (0.02)
HH Unemployed	0.21*** (0.02)	0.52*** (0.09)	0.15*** (0.02)	1.02*** (0.06)	0.17*** (0.01)	0.56*** (0.07)	0.13*** (0.01)	0.76*** (0.04)
HH Chronic ill-health	0.04*** (0.01)	0.17*** (0.04)	0.03*** (0.01)	0.16*** (0.03)	0.04*** (0.01)	0.12* (0.05)	0.02*** (0.01)	0.14*** (0.03)
HH Disability	0.11*** (0.01)	0.19*** (0.04)	0.05*** (0.01)	0.32*** (0.03)	0.12*** (0.01)	0.22*** (0.05)	0.05*** (0.01)	0.36*** (0.03)
HH Tenant	0.17*** (0.01)	0.56*** (0.05)	0.13*** (0.01)	0.80*** (0.03)	0.13*** (0.01)	0.42*** (0.06)	0.10*** (0.01)	0.57*** (0.04)
N	20454	20454	20454	20454	13090	13090	13090	13090

	SLOVENIA				CZECH REPUBLIC			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarial)								
Mixed	0.05** (0.02)	0.20* (0.09)	0.04*** (0.01)	0.10 (0.05)	0.02 (0.01)	0.09 (0.07)	0.04** (0.01)	0.05 (0.05)
Small self-emp.	-0.06** (0.02)	-0.07 (0.12)	-0.03 (0.02)	-0.27*** (0.08)	0.00 (0.02)	-0.00 (0.08)	-0.00 (0.01)	-0.01 (0.06)
Labor non-manual	0.13*** (0.02)	0.27** (0.10)	0.07*** (0.02)	0.34*** (0.07)	0.07** (0.02)	0.20* (0.08)	0.04** (0.01)	0.24*** (0.06)
Labor manual	0.14*** (0.02)	0.47*** (0.08)	0.10*** (0.01)	0.52*** (0.05)	0.10*** (0.01)	0.37*** (0.06)	0.09*** (0.01)	0.38*** (0.04)
Excluded	0.08** (0.03)	0.16 (0.12)	0.03 (0.02)	0.25** (0.09)	0.01 (0.06)	0.48* (0.20)	0.07 (0.04)	0.42* (0.17)
HRP Education (ref=Tertiary)								
Upper secondary	0.08*** (0.02)	0.44*** (0.10)	0.07*** (0.01)	0.09 (0.05)	0.11*** (0.02)	0.47*** (0.08)	0.08*** (0.01)	0.25*** (0.05)
Lower secondary ≥	0.16*** (0.02)	0.77*** (0.11)	0.14*** (0.02)	0.58*** (0.07)	0.20*** (0.02)	0.61*** (0.10)	0.12*** (0.02)	0.61*** (0.07)
HRP Divorced	0.05* (0.02)	0.13 (0.09)	0.03* (0.02)	0.22** (0.07)	0.01 (0.01)	0.20*** (0.05)	0.03** (0.01)	0.19*** (0.04)
HRP Single parent	0.05 (0.03)	0.08 (0.13)	0.02 (0.02)	0.18 (0.11)	0.04 (0.02)	0.18* (0.09)	0.07*** (0.02)	0.32*** (0.08)
HH 3+ children	-0.01 (0.03)	-0.14 (0.15)	-0.02 (0.02)	-0.13 (0.11)	0.10** (0.03)	0.18 (0.14)	0.09** (0.03)	0.38*** (0.11)
HRP Female	0.04*** (0.01)	0.09 (0.05)	0.03*** (0.01)	0.14*** (0.04)	0.08*** (0.01)	0.29*** (0.05)	0.06*** (0.01)	0.33*** (0.04)
HH Income (log equ.)	-0.29*** (0.01)	-0.97*** (0.07)	-0.20*** (0.01)	-1.16*** (0.05)	-0.33*** (0.01)	-0.94*** (0.06)	-0.22*** (0.01)	-1.08*** (0.04)
HH Unemployed	0.13*** (0.02)	0.36*** (0.09)	0.10*** (0.02)	0.77*** (0.07)	0.12*** (0.03)	0.39*** (0.10)	0.10*** (0.02)	0.80*** (0.08)
HH Chronic ill-health	0.08*** (0.01)	0.33*** (0.06)	0.07*** (0.01)	0.39*** (0.04)	0.06*** (0.01)	0.17** (0.06)	0.05*** (0.01)	0.22*** (0.04)
HH Disability	0.06*** (0.01)	0.32*** (0.06)	0.06*** (0.01)	0.36*** (0.04)	0.05*** (0.01)	0.18** (0.06)	0.04*** (0.01)	0.24*** (0.05)
HH Tenant	0.13*** (0.02)	0.48*** (0.10)	0.12*** (0.02)	0.77*** (0.07)	0.04*** (0.01)	0.25*** (0.05)	0.05*** (0.01)	0.28*** (0.04)
N	8939	8939	8939	8939	9852	9852	9852	9852

	CYPRUS				ESTONIA			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarial)								
Mixed	0.06* (0.03)	0.09 (0.13)	0.05* (0.02)	0.07 (0.08)	0.03 (0.02)	0.11 (0.11)	0.02 (0.02)	0.09 (0.07)
Small self-emp.	0.14*** (0.03)	0.15 (0.13)	0.07** (0.02)	0.30** (0.09)	0.02 (0.03)	-0.15 (0.11)	-0.02 (0.02)	-0.12 (0.09)
Labor non-manual	0.08* (0.04)	0.36* (0.17)	0.10** (0.03)	0.30** (0.11)	0.07** (0.02)	0.14 (0.11)	0.04 (0.02)	0.16* (0.08)
Labor manual	0.17*** (0.03)	0.35** (0.12)	0.12*** (0.02)	0.52*** (0.08)	0.11*** (0.02)	0.33*** (0.08)	0.08*** (0.02)	0.36*** (0.06)
Excluded	0.01 (0.06)	0.14 (0.17)	0.04 (0.04)	0.16 (0.16)	0.07 (0.07)	0.48* (0.24)	0.03 (0.04)	0.59** (0.19)
HRP Education (ref=Tertiary)								
Upper secondary	0.07** (0.02)	0.15 (0.12)	0.04 (0.02)	0.14 (0.08)	0.00 (0.02)	0.04 (0.08)	0.01 (0.01)	0.02 (0.05)
Lower secondary ≥	0.12*** (0.03)	0.47*** (0.13)	0.11*** (0.03)	0.48*** (0.09)	0.05* (0.02)	0.32** (0.10)	0.06** (0.02)	0.33*** (0.07)
HRP Divorced	0.04 (0.04)	0.47** (0.15)	0.10** (0.04)	0.42*** (0.12)	0.02 (0.02)	0.25** (0.08)	0.05** (0.02)	0.20*** (0.06)
HRP Single parent	0.12* (0.06)	-0.03 (0.19)	0.05 (0.05)	0.21 (0.18)	0.02 (0.03)	0.11 (0.12)	0.04 (0.02)	0.19* (0.10)
HH 3+ children	0.01 (0.03)	0.17 (0.18)	0.04 (0.04)	0.10 (0.11)	0.10** (0.04)	0.26 (0.16)	0.08* (0.04)	0.42*** (0.12)
HRP Female	0.07** (0.02)	0.22* (0.09)	0.04* (0.02)	0.33*** (0.07)	0.06*** (0.01)	0.38*** (0.06)	0.09*** (0.01)	0.33*** (0.04)
HH Income (log equ.)	-0.22*** (0.02)	-0.68*** (0.08)	-0.18*** (0.02)	-0.78*** (0.05)	-0.27*** (0.01)	-0.67*** (0.05)	-0.16*** (0.01)	-0.91*** (0.04)
HH Unemployed	0.14** (0.04)	0.71*** (0.20)	0.12** (0.04)	0.80*** (0.15)	0.16*** (0.02)	0.88*** (0.13)	0.21*** (0.03)	1.04*** (0.09)
HH Chronic ill-health	0.10*** (0.02)	0.13 (0.08)	0.07*** (0.02)	0.26*** (0.06)	0.05** (0.02)	0.01 (0.09)	0.01 (0.02)	0.11 (0.06)
HH Disability	0.05* (0.02)	0.31*** (0.08)	0.05** (0.02)	0.31*** (0.06)	0.11*** (0.02)	0.40*** (0.08)	0.09*** (0.02)	0.45*** (0.06)
HH Tenant	0.03 (0.03)	0.57*** (0.13)	0.11*** (0.03)	0.41*** (0.09)	0.07* (0.03)	0.04 (0.13)	0.02 (0.03)	0.20 (0.11)
N	3144	3144	3144	3144	4905	4905	4905	4905

	GREECE				SLOVAKIA			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salaried)								
Mixed	0.04 (0.02)	0.10 (0.12)	0.03 (0.02)	0.03 (0.07)	0.03 (0.02)	0.21* (0.10)	0.03 (0.02)	0.15* (0.07)
Small self-emp.	0.06** (0.02)	0.19 (0.10)	0.04* (0.02)	0.14* (0.07)	-0.05* (0.03)	-0.01 (0.13)	-0.04 (0.02)	-0.18 (0.10)
Labor non-manual	0.09*** (0.02)	0.32* (0.13)	0.08*** (0.02)	0.23** (0.09)	0.09*** (0.02)	0.62*** (0.12)	0.12*** (0.02)	0.59*** (0.09)
Labor manual	0.12*** (0.02)	0.48*** (0.10)	0.12*** (0.02)	0.46*** (0.07)	0.14*** (0.02)	0.56*** (0.09)	0.11*** (0.02)	0.64*** (0.07)
Excluded	0.02 (0.02)	0.28* (0.13)	0.05* (0.02)	0.11 (0.09)	0.02 (0.12)	0.51 (0.29)	0.02 (0.06)	0.60* (0.29)
HRP Education (ref=Tertiary)								
Upper secondary	0.08*** (0.02)	0.28** (0.09)	0.06*** (0.02)	0.07 (0.06)	0.10*** (0.02)	0.17 (0.12)	0.07*** (0.02)	0.23** (0.07)
Lower secondary ≥	0.16*** (0.02)	0.83*** (0.09)	0.17*** (0.02)	0.65*** (0.07)	0.19*** (0.03)	0.41** (0.15)	0.15*** (0.03)	0.69*** (0.11)
HRP Divorced	0.07** (0.02)	0.22* (0.11)	0.10*** (0.02)	0.34*** (0.09)	0.03 (0.02)	0.18 (0.10)	0.04 (0.02)	0.21* (0.08)
HRP Single parent	-0.02 (0.04)	0.25 (0.18)	-0.02 (0.04)	0.12 (0.14)	0.13*** (0.03)	0.10 (0.16)	0.07 (0.04)	0.39** (0.14)
HH 3+ children	0.04 (0.03)	0.58** (0.18)	0.14*** (0.03)	0.41*** (0.12)	0.01 (0.04)	0.36* (0.17)	0.06 (0.04)	0.38** (0.13)
HRP Female	0.05*** (0.01)	0.25*** (0.06)	0.05*** (0.01)	0.31*** (0.05)	0.05*** (0.01)	0.28*** (0.07)	0.05*** (0.01)	0.28*** (0.05)
HH Income (log equ.)	-0.34*** (0.01)	-1.00*** (0.04)	-0.30*** (0.01)	-1.35*** (0.03)	-0.28*** (0.01)	-0.81*** (0.07)	-0.22*** (0.01)	-1.10*** (0.05)
HH Unemployed	0.15*** (0.03)	0.66*** (0.13)	0.19*** (0.03)	0.96*** (0.10)	0.17*** (0.04)	0.76*** (0.15)	0.22*** (0.04)	1.33*** (0.12)
HH Chronic ill-health	0.03 (0.02)	0.27*** (0.08)	0.06*** (0.02)	0.26*** (0.06)	0.06*** (0.02)	0.25** (0.08)	0.06*** (0.02)	0.30*** (0.06)
HH Disability	0.06*** (0.02)	0.04 (0.08)	0.03 (0.02)	0.16* (0.06)	0.07*** (0.02)	0.31*** (0.08)	0.07*** (0.02)	0.33*** (0.06)
HH Tenant	0.09*** (0.01)	0.50*** (0.08)	0.12*** (0.01)	0.50*** (0.05)	0.03 (0.02)	0.40*** (0.11)	0.06** (0.02)	0.38*** (0.08)
N	6943	6943	6943	6943	5180	5180	5180	5180

	POLAND				PORTUGAL			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salaried)								
Mixed	0.06*** (0.01)	0.15 (0.09)	0.04** (0.01)	0.21*** (0.06)	0.09*** (0.02)	0.18 (0.15)	0.07** (0.03)	0.22* (0.11)
Small self-emp.	0.01 (0.01)	-0.31*** (0.08)	-0.04** (0.01)	-0.27*** (0.06)	0.09*** (0.02)	0.83*** (0.14)	0.16*** (0.03)	0.73*** (0.11)
Labor non-manual	0.10*** (0.02)	0.31** (0.10)	0.10*** (0.02)	0.47*** (0.07)	0.10*** (0.03)	0.65*** (0.16)	0.13*** (0.03)	0.57*** (0.13)
Labor manual	0.11*** (0.01)	0.45*** (0.08)	0.12*** (0.01)	0.59*** (0.05)	0.17*** (0.02)	1.08*** (0.13)	0.23*** (0.02)	1.13*** (0.10)
Excluded	0.09** (0.03)	0.15 (0.15)	0.07* (0.03)	0.33* (0.13)	0.10* (0.05)	0.92*** (0.24)	0.18*** (0.05)	0.88*** (0.21)
HRP Education (ref=Tertiary)								
Upper secondary	0.08*** (0.01)	0.37*** (0.09)	0.09*** (0.01)	0.20*** (0.06)	0.06 (0.03)	-0.45 (0.31)	-0.00 (0.04)	-0.14 (0.14)
Lower secondary ≥	0.15*** (0.02)	0.70*** (0.11)	0.15*** (0.02)	0.72*** (0.08)	0.11*** (0.03)	-0.15 (0.29)	0.06 (0.04)	0.12 (0.13)
HRP Divorced	0.03 (0.01)	0.39*** (0.09)	0.07*** (0.02)	0.45*** (0.07)	0.04 (0.02)	0.18 (0.14)	0.04 (0.03)	0.23* (0.12)
HRP Single parent	0.06** (0.02)	0.24* (0.12)	0.09*** (0.02)	0.36*** (0.10)	0.07* (0.03)	0.19 (0.20)	0.09* (0.04)	0.35 (0.19)
HH 3+ children	0.06** (0.02)	0.22 (0.11)	0.05** (0.02)	0.31*** (0.09)	0.05 (0.05)	0.71* (0.29)	0.14** (0.06)	0.82*** (0.23)
HRP Female	0.06*** (0.01)	0.44*** (0.05)	0.09*** (0.01)	0.41*** (0.04)	0.05*** (0.01)	0.55*** (0.08)	0.08*** (0.01)	0.59*** (0.07)
HH Income (log equ.)	-0.28*** (0.01)	-1.33*** (0.05)	-0.29*** (0.01)	-1.57*** (0.03)	-0.22*** (0.01)	-1.00*** (0.06)	-0.25*** (0.01)	-1.29*** (0.05)
HH Unemployed	0.11*** (0.02)	0.63*** (0.12)	0.14*** (0.02)	0.94*** (0.10)	0.10*** (0.02)	0.51*** (0.15)	0.11*** (0.03)	0.68*** (0.13)
HH Chronic ill-health	0.02 (0.01)	0.17** (0.06)	0.03** (0.01)	0.15*** (0.04)	0.05*** (0.01)	0.34*** (0.09)	0.09*** (0.02)	0.39*** (0.08)
HH Disability	0.07*** (0.01)	0.17** (0.05)	0.05*** (0.01)	0.33*** (0.04)	0.05*** (0.01)	0.37*** (0.09)	0.06*** (0.02)	0.44*** (0.08)
HH Tenant	-0.01 (0.02)	0.09 (0.12)	0.01 (0.02)	0.06 (0.10)	0.09*** (0.01)	0.47*** (0.09)	0.11*** (0.02)	0.66*** (0.08)
N	12745	12745	12745	12745	4877	4877	4877	4877

	LITHUANIA				HUNGARY			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarial)								
Mixed	0.04* (0.02)	0.30* (0.14)	0.07** (0.03)	0.29* (0.12)	0.02 (0.01)	0.26** (0.10)	0.05** (0.02)	0.23** (0.08)
Small self-emp.	-0.05 (0.03)	0.09 (0.15)	-0.03 (0.03)	-0.10 (0.13)	-0.02 (0.02)	-0.19 (0.10)	-0.03 (0.02)	-0.23* (0.09)
Labor non-manual	0.06* (0.02)	0.43** (0.14)	0.11*** (0.03)	0.39** (0.12)	0.04** (0.02)	0.33** (0.11)	0.07*** (0.02)	0.37*** (0.09)
Labor manual	0.07*** (0.02)	0.80*** (0.11)	0.15*** (0.02)	0.75*** (0.09)	0.07*** (0.01)	0.41*** (0.09)	0.11*** (0.02)	0.54*** (0.07)
Excluded	0.05 (0.05)	0.55* (0.25)	0.13* (0.05)	0.49* (0.22)	-0.01 (0.04)	0.17 (0.17)	0.10** (0.04)	0.10 (0.17)
HRP Education (ref=Tertiary)								
Upper secondary	0.08*** (0.02)	0.30* (0.12)	0.07*** (0.02)	0.30*** (0.09)	0.06*** (0.01)	0.44*** (0.09)	0.10*** (0.02)	0.44*** (0.07)
Lower secondary ≥	0.10*** (0.02)	0.26 (0.14)	0.08** (0.03)	0.37** (0.12)	0.11*** (0.02)	0.67*** (0.11)	0.15*** (0.02)	0.80*** (0.09)
HRP Divorced	0.05** (0.02)	0.27* (0.11)	0.08*** (0.02)	0.38*** (0.09)	0.02* (0.01)	0.28*** (0.07)	0.06*** (0.01)	0.33*** (0.06)
HRP Single parent	0.05 (0.03)	0.34 (0.19)	0.05 (0.04)	0.38* (0.17)	0.02 (0.02)	0.21 (0.12)	0.07** (0.03)	0.32** (0.11)
HH 3+ children	-0.00 (0.04)	0.42 (0.29)	0.05 (0.05)	0.33 (0.23)	0.03 (0.02)	0.58*** (0.14)	0.10*** (0.03)	0.66*** (0.13)
HRP Female	0.07*** (0.01)	0.54*** (0.07)	0.10*** (0.01)	0.58*** (0.06)	0.06*** (0.01)	0.28*** (0.06)	0.06*** (0.01)	0.38*** (0.05)
HH Income (log equ.)	-0.15*** (0.01)	-0.95*** (0.06)	-0.20*** (0.01)	-1.11*** (0.05)	-0.24*** (0.01)	-1.38*** (0.07)	-0.30*** (0.01)	-1.77*** (0.06)
HH Unemployed	0.09*** (0.02)	1.03*** (0.17)	0.17*** (0.03)	1.11*** (0.13)	0.08*** (0.02)	0.50*** (0.11)	0.14*** (0.03)	0.83*** (0.10)
HH Chronic ill-health	0.07*** (0.02)	0.76*** (0.09)	0.14*** (0.02)	0.73*** (0.08)	0.04*** (0.01)	0.09 (0.07)	0.03* (0.01)	0.20** (0.06)
HH Disability	0.03 (0.02)	-0.23* (0.09)	-0.02 (0.02)	-0.09 (0.08)	0.06*** (0.01)	0.48*** (0.07)	0.10*** (0.01)	0.56*** (0.06)
HH Tenant	0.08 (0.04)	0.96** (0.32)	0.17** (0.06)	1.16*** (0.25)	0.03* (0.02)	0.73*** (0.11)	0.13*** (0.02)	0.75*** (0.09)
N	5053	5053	5053	5053	9618	9618	9618	9618

	LATVIA				ROMANIA			
	Hurdle NBM		Conventional		Hurdle NBM		Conventional	
	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se	Risk b/se	Level b/se
HRP Social Class (ref=Salarariat)								
Mixed	0.03* (0.01)	0.12 (0.11)	0.01 (0.02)	0.14 (0.09)	0.02 (0.01)	0.11 (0.15)	0.04 (0.02)	0.20 (0.13)
Small self-emp.	-0.03 (0.02)	-0.08 (0.12)	-0.06* (0.02)	-0.21 (0.11)	0.02 (0.01)	0.28* (0.12)	0.02 (0.02)	0.28* (0.11)
Labor non-manual	0.02 (0.02)	0.31** (0.11)	0.03 (0.02)	0.24* (0.10)	0.03 (0.02)	0.51** (0.16)	0.07* (0.03)	0.57*** (0.14)
Labor manual	0.06*** (0.01)	0.46*** (0.10)	0.08*** (0.02)	0.50*** (0.08)	0.04*** (0.01)	0.62*** (0.11)	0.09*** (0.02)	0.72*** (0.10)
Excluded	0.04 (0.05)	0.14 (0.28)	-0.04 (0.06)	0.18 (0.27)	0.02 (0.03)	0.45** (0.16)	0.03 (0.03)	0.46** (0.15)
HRP Education (ref=Tertiary)								
Upper secondary	0.03* (0.01)	0.46*** (0.09)	0.06*** (0.02)	0.33*** (0.08)	0.05*** (0.01)	0.90*** (0.13)	0.16*** (0.03)	0.80*** (0.11)
Lower secondary ≥	0.07*** (0.02)	0.62*** (0.11)	0.10*** (0.02)	0.61*** (0.10)	0.10*** (0.02)	1.26*** (0.15)	0.21*** (0.03)	1.28*** (0.13)
HRP Divorced	-0.01 (0.01)	0.11 (0.08)	0.00 (0.02)	0.06 (0.07)	0.02 (0.01)	0.15 (0.11)	0.02 (0.02)	0.23* (0.10)
HRP Single parent	0.02 (0.02)	0.38* (0.15)	0.11*** (0.03)	0.39** (0.13)	0.03 (0.02)	0.37* (0.19)	0.08* (0.03)	0.44* (0.18)
HH 3+ children	0.02 (0.03)	0.70** (0.22)	0.13*** (0.04)	0.73*** (0.18)	0.06* (0.03)	0.72*** (0.19)	0.13*** (0.04)	0.88*** (0.19)
HRP Female	0.04*** (0.01)	0.40*** (0.07)	0.09*** (0.01)	0.41*** (0.06)	0.01 (0.01)	0.28*** (0.06)	0.03* (0.01)	0.27*** (0.06)
HH Income (log equ.)	-0.12*** (0.01)	-0.85*** (0.05)	-0.19*** (0.01)	-1.04*** (0.04)	-0.12*** (0.01)	-0.74*** (0.04)	-0.20*** (0.01)	-1.09*** (0.05)
HH Unemployed	0.09*** (0.01)	1.00*** (0.12)	0.23*** (0.02)	1.20*** (0.10)	0.03 (0.03)	0.93*** (0.21)	0.14*** (0.04)	1.08*** (0.20)
HH Chronic ill-health	0.07*** (0.01)	0.54*** (0.09)	0.13*** (0.02)	0.57*** (0.08)	0.02* (0.01)	0.33*** (0.07)	0.06*** (0.01)	0.38*** (0.07)
HH Disability	0.05*** (0.01)	0.41*** (0.09)	0.07*** (0.02)	0.48*** (0.08)	0.02* (0.01)	0.30*** (0.07)	0.04** (0.01)	0.34*** (0.07)
HH Tenant	0.04** (0.01)	0.81*** (0.10)	0.12*** (0.02)	0.88*** (0.09)	0.04** (0.02)	0.82*** (0.23)	0.13*** (0.03)	0.86*** (0.19)
N	5720	5720	5720	5720	7664	7664	7664	7664

	<b>BULGARIA</b>			
	<b>Hurdle NBM</b>		<b>Conventional</b>	
	Risk	Level	Risk	Level
	b/se	b/se	b/se	b/se
<b>HRP Social Class</b> <i>(ref=Salariat)</i>				
Mixed	0.02 (0.01)	0.29* (0.13)	0.03 (0.02)	0.29* (0.12)
Small self-emp.	-0.00 (0.01)	0.21 (0.13)	0.01 (0.02)	0.13 (0.12)
Labor non-manual	-0.01 (0.01)	0.43*** (0.13)	0.04 (0.02)	0.31** (0.11)
Labor manual	0.02* (0.01)	0.58*** (0.11)	0.07*** (0.02)	0.54*** (0.10)
Excluded	0.00 (0.03)	1.04*** (0.25)	0.12*** (0.04)	1.02*** (0.22)
<b>HRP Education</b> <i>(ref=Tertiary)</i>				
Upper secondary	0.04*** (0.01)	0.41*** (0.11)	0.04* (0.02)	0.44*** (0.10)
Lower secondary ≥	0.06*** (0.01)	0.63*** (0.13)	0.08*** (0.02)	0.78*** (0.12)
HRP Divorced	0.01 (0.01)	-0.07 (0.11)	0.01 (0.02)	-0.04 (0.10)
HRP Single parent	-0.00 (0.02)	0.29 (0.25)	0.01 (0.04)	0.37 (0.22)
HH 3+ children	-0.03 (0.04)	0.38 (0.25)	0.02 (0.05)	0.50* (0.25)
HRP Female	0.02* (0.01)	0.48*** (0.06)	0.07*** (0.01)	0.49*** (0.06)
HH Income ( <i>log equ.</i> )	-0.10*** (0.01)	-1.54*** (0.06)	-0.26*** (0.01)	-1.84*** (0.05)
HH Unemployed	0.03* (0.01)	0.75*** (0.13)	0.11*** (0.02)	0.89*** (0.11)
HH Chronic ill-health	0.03*** (0.01)	0.09 (0.08)	0.02 (0.01)	0.18** (0.07)
HH Disability	0.01 (0.01)	0.38*** (0.08)	0.04*** (0.01)	0.41*** (0.07)
HH Tenant	0.02 (0.01)	0.06 (0.18)	-0.00 (0.03)	0.16 (0.15)
N	5549	5549	5549	5549

## **Paper 4:**

### **Identifying people in poverty:**

#### **A multidimensional deprivation measure of poverty for the EU**

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## **Abstract**

In this article, I propose a multidimensional deprivation measure of poverty for the EU with the aim of improving on some of the conceptual and data problems that cause measurement error in the existing deprivation scales. The paper stands on the claim that a stand-alone deprivation measure can be adequate, both conceptually and empirically, to capture poverty defined in Townsendian terms. Yet the existing deprivation scales have three conceptual problems such as data-driven specifications, missing dimensions and neglecting dimensionality, and also suffer from three data problems such as cross-cultural equivalization, behavioral choices and reporting error. To address the conceptual problems, I offer a concept-led methodology to construct a multidimensional measure. To address the data problems, I apply a post-hoc adjustment strategy using dual criteria of income poverty and financial strain. The proposed measure has four dimensions, basic goods, health, education, leisure and social relationships, where each dimension is evaluated separately with a relevant scale. When compared to the formal EU 2020 poverty target measure, the adjusted proposed measure is more likely to capture people with needs and lower resources as well as those in less affluent countries than those in more affluent countries. The adjusted proposed measure can be used as a stand-alone indicator to identify a target population for policy; or the unadjusted proposed measure can be combined with an income poverty measure to identify a worst-off group within that target population.

**Keywords:** multidimensional measurement of poverty; missing dimensions; data-driven specifications; dimensionality of poverty; cross-cultural invariance; reporting error; EU 2020 poverty target measure; concept-led measurement; identifying dimensions

## 1. Introduction

Deprivation scales are of greater interest in European poverty research. Most of the formal poverty measures now employ a deprivation scale albeit usually alongside income poverty measures. For example, in the EU 2020 poverty target, people in at-risk-of-poverty-or-social exclusion are defined as those experiencing severe material deprivation, income poverty *or* low work intensity (union approach); in the UK's child poverty measure and Ireland's official poverty measure, people in poverty are defined as those experiencing material deprivation *and* income poverty (intersection approach).

In both approaches, deprivation scales are combined with income poverty measures either as complementary or supplementary.<sup>52</sup> The main reason behind this practice is the existence of certain limitations related to the validity of both income and deprivation measures. Combining income and deprivation measures, it is argued, can help better identify the scale of the problem to be addressed by anti-poverty policies in EU member states.

However, conceptually, income and deprivation measures are alternatives to each other (if the aim is to measure poverty defined in Townsendian terms); and when constructed appropriately, an income or a deprivation measure can, in theory, be adequate to identify poverty (defined in Townsendian terms) (see also Hick, 2014).<sup>53</sup> Moreover, Hick (2014)

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<sup>52</sup> Different uses of deprivation measures is arisen due to different interpretations of Townsendian definition of poverty (Berthoud & Bryan, 2011), the empirical finding of a large mismatch between low income and material deprivation (see Nolan and Whelan, 2011 for a review), the disagreements about how to go about this mismatch empirically (Hick, 2014), and various practical and political considerations related to measuring poverty in a cross-national context (Copeland and Daly, 2012; Maître et al., 2013).

<sup>53</sup> Relative deprivation theory defines a process in which lack of resources results in unmet material and social needs and hence exclusion from ordinary living patterns. Different interpretations are made on which part of this definition represents the essence of poverty (Berthoud and Bryan, 2011). While Townsend considers poverty primarily as a lack of resources and exclusion from ordinary living as the consequences of it, others consider poverty as exclusion

shows that, despite their current limited form, it is the deprivation and not the income measure that is particularly useful in identifying the people with a pronounced risk of multiple deprivation in the UK. Nevertheless, Hick argues, the considerably non-ideal nature of existing deprivation measures still limit their ability to distinguish between poverty and non-poverty, and therefore “advancing the measurement of material deprivation beyond its present, relatively rudimentary state represents an important priority for poverty research (Hick, 2014: 1101)”.

Recent proposals by Whelan & Maître (2012) and Guio et al. (2016) improve existing deprivation scales using an extended set of items collected at the EU-SILC survey’s material deprivation module. Yet, as empirically shown in Paper 1 and 2 of this thesis, there are further conceptual problems such as missing dimensions, data-driven specification and neglect of multidimensionality. In addition to these conceptual problems, there are also practical data issues related to the subjectivity of deprivation data and its use in a cross-national setting. All of these conceptual and data problems are directly consequential for measurement, therefore might result in missing people in poverty (Type II error) or wrongly identifying people in poverty (Type I error).

Developing on the critiques of Paper 1 and 2, and Hick (2014), the main objective of this article is to propose a multidimensional deprivation measure of poverty for the EU which mitigates existing measurement problems to the extent possible given available data,

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from ordinary living and the cause being the lack of resources. Another view would be to consider the whole process including both resources and exclusion components as the experience of poverty. Still, regardless of the view taken, income (as a proxy of lack of resources) and deprivation (as a proxy of exclusion from ordinary living patterns) represent alternative measures of the same phenomenon, and both can be a direct or an indirect measure of poverty depending on the view taken. For example, if poverty is defined as exclusion from ordinary living which is caused by lack of resources, a deprivation measure including enforced criterion can be used a direct measure of poverty; or an income measure which adequately considers non-cash economic resources, saving and debt as well as varying needs due to individual and household characteristics can also be employed as an indirect measure of poverty (or vice versa).

and show a better performance in identifying people in poverty compared to the existing measures. Such a measure can be used, with certain adjustments, as a poverty target itself, or if proved politically useful, can also be combined with income poverty measures to identify the worst-off groups.

In this context, the article is focused on constructing a concept-led, comprehensive and multidimensional deprivation measure of poverty, and examining its validity relative to the existing poverty measures. The next section summarizes the existing measures and possible problems that cause measurement error (Type I and II) as well as the proposal of the paper. Then, i) to inform the designing of measures, the meaning of poverty conceptualized within relative deprivation framework is elaborated and dimensions of poverty are identified and defined; ii) relevant scales representing each of these dimensions are constructed and validated; iii) validity of the proposed measure is examined by a comparison to the EU 2020 poverty target on their ability to capture those with lower resources and higher needs using a multinomial logistic model. The analysis is held for 25 EU countries using EU-SILC survey with its material deprivation module.

## **2. Identifying people in poverty – existing measures, their problems and proposals for mitigating possible measurement error**

In European poverty research, poverty is generally defined within the relative deprivation framework of Townsend (1979). In this framework, individuals are considered to be in poverty when “their resources are so seriously below those commanded by the average individual or family that they are excluded from ordinary living patterns, customs and activities”. This definition makes a clear link between command over resources and conditions of life, and defines a process in which a lack of resources causes relative deprivation and hence an inability to participate in society.

One way to assess such poverty is using income measures which aim to measure adequacy of economic resources for social participation. In such measures, household disposable income (usually equivalized for household size and composition) is used as a proxy for resources, and a poverty line is set to represent the level below which resources are considered inadequate for participating in society. However, income as we measure does not include publicly provided services, in-kind benefits, home production, saving and borrowing, past investments in durables, and house ownership and assets, which are important factors affecting command over resources (Nolan & Whelan, 2007). Also, adequacy of resources depends not only on resources but also on geographical price variation and various individual and households needs not accounted in the existing forms of these measures (Ravallion, 1996). For example, varying needs for health care, child care, social care, education and work (e.g. transportation) are accounted neither in disposable income nor in poverty line estimates. Therefore, it is not clear that measures such as 60% of median represent a level of exclusion from ordinary living patterns especially when applied in a cross-national context (Goedemé & Rottiers, 2011).<sup>54</sup>

Another issue is the measurement error in income data collected based on household surveys. For example, validating against administrative data, Meyer & Mittag (2015) show significant underreporting of the receipt and level of benefits in household surveys, varying between 30%-60% depending on the type of benefit, which has a significant impact on the numbers of poverty.<sup>55</sup> All these issues create problems in the accuracy of

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<sup>54</sup> However, see the recent efforts to improve on some of these problems based on reference budgets in the EU (Penne et al., 2016; Decerf et al., 2017), and supplemental poverty measure in the US (Short, 2011).

<sup>55</sup> The reasons for under-reporting are various including memory bias related to timing, amount or the recipient of the benefit; confusing program names; stigma and shame; and, sensitivity of income information (Meyer et al., 2009).

income poverty measures in identifying the people in poverty. Indeed a recent study using reference budgets has shown that, in some less affluent EU countries, some of those who are not identified as in poverty by a relative income poverty measure (60% of median) still cannot afford to meet their needs for food and housing (Goedeme et al., 2017).

Deprivation scales are raised partly as a response to these problems. Such measures are constructed as single scales comprising multiple binary non-monetary deprivation items, where each item shows lack of possession of certain goods and services, or lack of participation in certain social activities due to a lack of resources (with an enforced criterion).

In principle, given that they are outcome measures and reflect deprivation due to affordability problems, deprivation measures are free from most of the aforementioned problems of income poverty measures. Deprivation measures represent inadequacy of economic resources for having the conditions of life necessary for social participation which, at least in theory, take into account various sources of income such as assets and debt, in-kind benefits and public services. Also, since needs are directly evaluated, the variation in needs across individuals or households does not construe a problem unless each relevant need is included into the measures. For example, variation in needs for child care can be accounted by including an item that represent cost-related unmet needs in child care. Those households who do not have the need (e.g. without children), or who have the need but satisfied (e.g. with children and get free child care) will score zero, while those who have cost-related unmet need will score one from the deprivation item.

However, in practice, existing material deprivation scales still suffer from three conceptual and three data problems, and both types of problems might cause Type I and II error in measurement (see Table 1).

**Table 1: Problems of existing deprivation scales and possible related measurement error**

<b>Problem</b>	<b>Type I error – overestimation</b>	<b>Type II error – underestimation</b>	<b>Proposed solution</b>
<b><i>Conceptual problems</i></b>			
Data-driven specification	X	✓	Concept-led design
Missing dimensions	X	✓	Comprehensiveness
Neglecting dimensionality	X	✓	Multidimensionality
<b><i>Data problems</i></b>			
Cross-country equivalence	✓	X	Post-hoc adjustment
Behavioral choices	✓	✓	Post-hoc adjustment
Reporting error	✓	✓	Post-hoc adjustment

Regarding conceptual problems, the first is missing dimensions. Due to data limitations, the existing measures cover some but not all aspects of poverty. For example, they do not consider needs related to health care, child and social care and education. As a result, people who experience poverty related to missing dimensions are not captured unless they are also deprived in existing dimensions. For example, Paper 1 and 2 of this thesis show that existing deprivation scales particularly fail to identify people in poverty with needs in health care, child care, social care and education. The second is the data-driven design. Although relevant deprivation items are primarily selected based on theory, deprivation scales are constructed based on data-driven methods (exploratory factorial techniques). Therefore, the specification of resulted scales is ultimately data-

driven. Given data limitations, one would expect existing scales to be inadequate for capturing different experiences of poverty. The third is the use of non-zero thresholds in a unidimensional scale (and the neglect of dimensionality). The existing measures are designed as unidimensional scales which collapse and evaluate different types of poverty in the same measure. Non-zero thresholds are then used to identify the most deprived and exclude non-poverty cases. Yet in such a measure, a person who is deprived only in one dimension (e.g. basic goods, health care or education access, social activities) might be wrongly identified as non-poor due to the use of non-zero thresholds. Therefore, non-zero thresholds in a unidimensional scale might unintentionally exclude some poverty cases.

Regarding data problems, the first is cross-cultural equivalence of deprivation items and measures. As also argued by Gábos & Goedemé (2016) and Hick (2014), it is not clear whether the specific selected items or overall measures have the same social meaning in all EU countries. Kis et al. (2015), for example, argue that while 9-item overall deprivation measure is not affected by cultural differences, the attitudes towards holiday, car and saving (ability to pay unexpected expenses) vary across countries. This item-level non-invariance is particularly a concern as cross-country variance for some items are unexpectedly high. For example, the deprivation rate for “ability to afford to buy new clothes” is 2% in Netherlands and 65% in Bulgaria; for “ability to afford to replace worn-out furniture” is 3% in Italy, while it is around 80% in Bulgaria; for “ability to afford one week annual holiday away from home is 11% in Denmark and 76% in Romania. To a certain extent, such high rates in less affluent countries raise suspicion about the validity of these items as deprivation indicators; at the same time, these items have high discriminatory powers and are the main source of limited variance within affluent

countries. Therefore, the items included given their discriminatory value in affluent countries might cause an overestimation for the less affluent countries.

The second is measurement error due to behavioral choices. One main feature of direct outcome measures is that achieved outcomes reflect resource and need constraints as well as preferences. One of the main appeal of deprivation measures is their ability to distinguish constraints from preferences through the method originally proposed by Mack & Lansley (1985). In this method, people are asked to evaluate whether a specific deprivation is a result of affordability problems or their own choice. Although such affordability questions seem to capture well the resource constraints (Hick, 2013), the subjective nature of the question might still bring about certain biases in judgement. One main reason is that preferences are not formed independent of individual characteristics (e.g. economic conditions, age, health or personality etc.) or preferences might adapt to existing conditions (Halleröd, 2006; Crettaz & Suter, 2013). As a result, certain groups such as elderly or those with low incomes are more likely to say “they do not want” certain items especially when their material situation is worse than before (Halleröd, 2006b; Hick, 2013; McKnight, 2013); or, elderly might be less likely to attribute deprivation to the shortage of money (Berthoud et al., 2006).<sup>56</sup> Both of these issues might result in underestimation of poverty numbers. On the other hand, McKay (2004) also argues that some of those who lack many necessities at the same time possess other non-necessities which reflects the heterogeneity of preferences and sign an overestimation of poverty numbers.

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<sup>56</sup> For example, Siminski & Yerokhin (2012) show that one-third of the variation in deprivation between elderly and non-elderly population is explained by unobserved characteristics, which they interpret as behavioral choices; on the other hand, Hildebrand et al. (2017) show that differences in deprivation between native and migrant population in Luxembourg can almost totally be explained by differences in resources.

The third is reporting error, for example due to social desirability bias or misinterpretation of questions. Evidence suggests that answers to sensitive questions are often distorted by social desirability bias. To avoid embarrassment and distress, individuals tend to underreport outcomes that are deemed as socially undesirable such as deprivation. For example, although Siminski & Yerokhin (2012) find no evidence that reporting bias contributes to the age-gradient in deprivation, Gundersen & Ribar (2011) argue that food insecurity in the US is underreported due to social desirability bias. This evidence is also supported by the study of Breunig & McKibbin (2011) which shows that individuals report higher financial difficulty in written, self-completion questionnaire than in the computer-assistant face-to-face interview as the prior is exposed to less social desirability bias due to being a more impersonal method. The effect of survey mode is a serious concern for deprivation measures as the data collection method in EU-SILC significantly vary across countries. Yet another issue would be the misinterpretation of deprivation or affordability questions. As reported widely (e.g. Nolan & Whelan, 2011: 69), deprivation can be found even on the highest income groups which might be related to misunderstandings about what is being asked in relation to deprivation items (e.g. going for a holiday) or miscalculations related to affordability (Mack & Lansley, 1985) , and both of these issues might cause overestimation of poverty.

In order to address the conceptual problems, the aim here is to construct a deprivation measure of poverty which is i) *concept-led* where the identification of dimensions and items, and the specification of overall design are primarily determined from the theoretical definition of poverty; ii) *more comprehensive* including aspects of poverty that are missing in existing deprivation scales, and iii) *multidimensional* where each dimension is evaluated separately with a relevant scale before reaching an overall evaluation of poverty.

To address possible biases related to data problems, a *post hoc* adjustment strategy is applied to the proposed deprivation measure using both income poverty and financial strain as dual criteria. This adjustment strategy is explained in detail in the operationalization section; before that, the next section focuses on elaborating the concept of poverty its dimensions to address the conceptual problems.

### **3. Elaborating the concept of poverty and its dimensions**

In this section, the conceptual meaning of poverty within relative deprivation framework is elaborated to inform the design of the measure considering the specification of dimensions. The main issue is to explain the meaning of participation in society (or exclusion from ordinary living patterns). Townsend developed relative deprivation framework based on a critique of the prevailing understanding of poverty at the time, so-called biological approach, in which poverty is defined as inability to afford “minimum necessities for the maintenance of merely physical efficiency (Rowntree, 1901: 86)”. Amongst many others, Townsend’s main critique was on the narrow understanding of poverty as mere subsistence which isolates the phenomenon from its societal context, and ignores the demands or social obligations imposed upon individuals by the society (Townsend, 1962; 1993). Individuals, merely by being members of a society, not only have biological but also social and psychological needs which are created and sustained by the social institutions and welfare systems (Townsend, 1979: 50-59; Lister, 1990). Accordingly, Townsend defines relative deprivation and poverty in the context of social relationships, social participation and citizenship:

“People are relatively deprived if they cannot obtain, at all or sufficiently, the conditions of life – that is, the diets, amenities, standards and services – which allow them to play the roles, participate in the relationships and follow the

customary behavior which is expected of them by virtue of membership of society. If they lack or are denied resources to obtain access to these conditions of life and so fulfill membership of society they may be said to be in poverty. People may be deprived in any or all of the major spheres of life [...] performing a variety of roles in fulfilment of social obligations (Townsend, 1993: 36)”

Relative deprivation is the inability to obtain the conditions of life and hence meet certain needs required for social participation (or in general participation into society), while poverty is the inability to meet these needs due to not having enough economic resources. In this framework, social participation is defined in terms of performing expected social roles as citizens, parents, workers, friends, relatives, neighbors etc (Lister, 1990); dimensions of poverty can be considered as the different needs required for being able to perform social roles, while relevant deprivation items represent the conditions life required to satisfy these needs. Townsend further elaborates these areas of need based on some instances of the poverty experience:

“... people do not just go hungry or get cold for lack of fuel or clothing. And their health is not just measurably worse for want of income. Families may no longer be able to go even the cheapest holiday, or invite friends to their homes, or send their children to school when money has to be provided for some special function or outing, or respond to urgent requests from church of which they are members. Old age pensioners may fail to join friends in a club or a pub because they lack resources to share the costs. Young families may become homeless because of a shortage of, or a deterioration in, public housing, or they may find they cannot maintain both the costs of a home and the costs of meeting other obligations, like travelling to find, or keep in, paid work, or caring for close elderly and disabled

relatives. The balancing act becomes a nightmare. Their essential needs are defined in terms of family dishonor and social ostracism as well as individual hunger and cold (Townsend, 1993: 37)”

The needs go from the basic goods (e.g. food, clothing and shelter) to other essentials such as education, health and caring (e.g. child and social care) as well as to more social ones such as leisure and social relationships (e.g. meeting friends, go on a holiday). Before detailing each of these dimensions and the conditions of life required for meeting these needs based on relevant empirical evidence, it is important to describe three other features of these needs which can be derived from this definition.

*First*, the roots of these needs are not only physical but also can be social or psychological. This follows from Townsend’s critique of the biological approach and underlies his relative deprivation approach which considers needs as socially constructed, reflecting “a range of social expectations and responsibilities, and also dictates of laws (Lister, 2004:24)”. *Secondly*, these needs are considered as absolute and universal, while the conditions of life required to meet these needs are relative to the society (see also Gordon et al., 2000) as well as to individual and household characteristics (e.g. based on age, health and household demographics). It has parallels to Sen's (1983) argument that capabilities are absolute while the commodities required to reach capabilities are relative, and Doyal & Gough's (1984) theory, where basic human needs (health and autonomy) are absolute and universal while the commodities to satisfy these needs are relative. *Thirdly*, each need is considered as a component of poverty yet without any hierarchy among them – the value given to each dimensions might vary across individuals depending on their specific conditions as well as preferences and choices. Therefore, it is important to consider each need separately, as

when money is not adequate, individuals might choose different needs to satisfy, and an enforced deprivation in even one defines a poverty experience.

### **3.1. Identifying and defining dimensions of poverty**

Given the elaborated definition above, the explanations of the identified dimensions and their justifications are summarized below. The main criterion to identify dimensions is that the dimensions should represent areas of needs that are essential for social participation or performing social roles. Then each identified dimension and their components are elaborated, where the components represent the conditions of life required to meet needs for social participation but might be lack due to a resource constraint (inability to afford). Therefore, I briefly report some empirical evidence on the relationships between i) needs and social participation, where social participation is considered more generally as the ability to adequately fulfil responsibilities related to work, family and wider community, and ii) needs and low income to identify the goods, services and activities (conditions of life) required to satisfy these needs but might be lack due to a resource constraint.

Following this framework, four dimensions are identified, namely needs for basic goods, health, education, and leisure and social relationship. It is important to note here that this practice of deriving dimensions is confined to the dimensions that are possible to measure given available data. In principal, for example, needs related to caring (child and social care) should also be considered.

**Basic goods.** This dimension represents the need for basic goods such as food, clothing and shelter for social participation. This dimension closely resembles Rowntree's (1901) idea of absolute poverty where such goods are described as

necessary for subsistence and physical maintenance. Recent evidence shows increasing trends in the levels of food insecurity across Europe, mostly due to financial difficulties (Loopstra et al., 2015; 2016). Food insecurity is shown to have an impact on managing chronic diseases and mental health problems (Gundersen & Ziliak, 2015; Pryor et al., 2016) and school children's academic performance and social skills (Jyoti et al., 2005). Similarly, lack of appropriate clothing is essential for keeping physical health, but also as a social status symbol, has implications for social participation in the context of work, friendship and social activities, especially for women and children (Francis, 1992; Turner-Bowker, 2001). Regarding shelter, the most immediate issue is habitancy. Recent evidence from an emerging area of research in the US has shown the high prevalence of eviction among inner-city poor, especially for women, which increases the chances of job loss, family dissolution and mental health problems and brings about prolonged period of homelessness (Desmond, 2012).<sup>57</sup> Another relevant problem related to housing is fuel poverty, which may result in deteriorations in physical and mental health (Thomson & Thomas, 2015) and affects everyday practices and social relations (Middlemiss & Gillard, 2015). The last component of shelter deprivation is the inadequacy of housing facilities such as space, furniture and physical building. Reviewing evidence based on some housing interventions, Thomson & Thomas (2015) show that improvements in domestic space and design appropriate to needs is linked to improved mental health, reduced risk of chronic illness, improved relationships and social interactions, and increased opportunities for leisure and study in the household. All these three housing problems are commonly related to other types of deprivations and lack of money, while also affecting people's ability to take up employment (Tunstall

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<sup>57</sup> In Europe, especially after 2008 mortgage crisis, eviction and housing has also become a significant concern especially for the Southern countries.

et al., 2013). Therefore, relevant components for this dimension are inability to afford i) food, ii) clothing, iii) habitancy, iv) fuel and v) housing facilities.

**Health.** This dimension represents the needs related to health for social participation. Health problems are important barriers to social participation in various ways. People with poor health (e.g. self-rated bad health, having chronic health or disability problems) generally have lower employment rates, are more likely to exit employment earlier, have fewer working hours and lower earnings; also, specifically those with disability, are less likely to have completed upper secondary education and more likely to have dropped out of school prematurely (OECD, 2010; 2016; van Rijn et al., 2014). A recent scoping review identifies lower participation of people with disabilities in leisure activities and schools partly due to financial problems (Hästbacka et al., 2016). Although, it is hard to identify specific cases of health problems directly caused by lack of money, a recent review has shown that low income is an important determinant of health through its material, psycho-social and behavioral effects (Benzeval et al., 2014). The relevant part here is the material effect which regards the ability to afford health-promoting goods, avoiding harmful environment and engaging in a way of life that promotes health.<sup>58</sup> Therefore, relevant components of this dimension are inability to afford i) health care services, ii) health-promoting goods, iii) avoiding harmful environment, and iv) a healthy diet and living style.

**Education.** This dimension represents the needs related to education for social participation. Education is an essential element in various aspects of participation into society. Formal educational achievement as well as cognitive and non-cognitive skills are important determinants for many important outcomes such as labor market

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<sup>58</sup> The psycho-social effect includes stress of economic scarcity; the behavioral effect considers the impact of low income context on health behavior, specifically on risky health behavior.

participation and health (Conti, Heckman, & Urzua, 2010), health behaviors (Cutler & Lleras-Muney, 2006), and social capital (Helliwell & Putnam, 2007). Access to higher education itself is even sometimes considered as a component of participation into society (Archer et al., 2005). Also, beyond formal educational achievement, cognitive and non-cognitive skills are mainly shaped in early ages (Kautz et al., 2014). Parents are still the primary responsible from child education which have extra financial costs not only due to tuition fees but also extra costs related to transport, school lunches, uniform and textbooks, school trips and extracurricular activities (Bradshaw & Finch, 2002). In this context, access to information is instrumental for education and learning for young people (Davies et al., 2015), but also for adults an important medium for social engagement (Bargh & McKenna, 2004), job search (Kuhn & Mansour, 2014) and access to financial services (Claessens, 2006). In that respect, component of this dimension are ability to afford i) formal education, other goods and services that support ii) education (e.g. working space) and iii) learning of children (e.g. toys, books) and iv) provides access to information (e.g. internet).

***Leisure and social relationship.*** This dimension represents the needs related to leisure and social relationship for social participation. The lack of adequate social and physical leisure activities is linked to negative health outcomes, high stress levels and social isolation (Passias et al., 2017) as well as increase the feelings of social support (Coleman & Iso-Ahola, 1993) and help to create social networks which can lead to enhanced social capital (Putnam, 2001; Van Ingen & Van Eijck, 2009) and better health (Smith & Christakis, 2008). Therefore, leisure and social activities are essential to sustain social relationships. On the other hand, lack of adequate economic resources has shown to have detrimental effects on relations with friends and relatives, and resource potential of networks (Mood & Jonsson, 2016; Böhnke & Link, 2017). Also, the

ability to participate in leisure activities is determined both by affordability and having sufficient leisure time, where the latter is related to hours of employment, family responsibilities and gender (Bittman, 2002; Passias et al., 2017). Therefore, components of this dimension are inability to (economically) afford i) having leisure time, ii) leisure activities and iii) social activities.

In Table 2, the proposed dimensions of poverty and possible relevant deprivation items are presented. As informed by the theoretical definition, each of these needs is a constitutive component of poverty, without any hierarchy among them; hence deprivation in one of them defines a poverty experience. For example, not being able to afford conditions of life which are required to satisfy the need for basic goods defines a poverty experience, since having unmet need for basic goods prevents individuals from performing their social roles. In the following sections, the aim is to operationalize this conceptualization and construct a multidimensional deprivation measure of poverty that can capture such poverty to the extent possible given available data. The data source is described in the next section.

**Table 2: Identified dimensions of poverty and their components**

<b>Dimensions</b>	<b>Components of each dimension</b>
Basic goods	Inability to afford adequate i) food, ii) clothing, iii) habitancy, iv) fuel and v) housing facilities
Health	Inability to afford i) health care services, ii) other health-promoting goods, iii) avoiding harmful environment, and iv) a healthy diet and living style
Education	Inability to afford i) formal education, goods and services that ii) supports education and iii) learning for children, and iv) provide access to information
Leisure and social relationships	Inability to afford i) sufficient leisure time, and participating in ii) leisure and iii) social activities

#### 4. Data

As the main data source for the contemporary poverty studies in the EU, EU-SILC 2009 survey is used. EU-SILC is a comparable microdata on income, deprivation and poverty collected across 29 European countries. 2009 wave includes a special material deprivation module. The main survey includes deprivation indicators collected generally at the household level (e.g. ability to keep home adequately warm), while in the deprivation module, there are further questions asked at the individual (e.g. about basic needs and leisure) as well as child level (answered by the household reference person). Therefore, the items are collected at three different levels: household, adult and child. The details of the deprivation indicators are described at Table A1 in Appendix.

The poverty rates are calculated at the individual level. To do this, the items collected at the household level are distributed to each household member; for the items collected at the adult level, the household is considered as deprived if one adult is deprived;<sup>59</sup> and for the items collected at the child level, a household is considered deprived if a child is deprived. Also, some items collected both at the adult and child level (e.g. holiday), which are merged given the procedure explained above. Therefore, if any adult or child is deprived of a specific item, each member of the household is considered as deprived of this specific item in the proposed measure.

As shown in Table A2 in Appendix, the rate of missing for each deprivation indicator is very low (below 0.4%) which in total corresponds to 1.7% of total sample. Although the rate of missing data varies across countries (e.g. no missing in Cyprus; 4.5% in Denmark), it is below 5% in all countries (see Table A3 in Appendix). The only exception

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<sup>59</sup> This procedure (counting the household as deprived if at least one adult is deprived) is necessary as for some countries (“register countries”), the information is available only for the household reference person.

is Sweden which has 45% missing rate and hence excluded from analysis. Also, Malta is excluded due to data problems for the variables used in the validity analysis (described further in the relevant section).

## **5. Operationalization of the proposed measure**

Given the proposed conceptual structure and definition of poverty, operationalization is mainly an exercise of creating reliable scales for the components of each dimension. The reason for this is related to the nature of poverty as defined. Poverty is considered as not being able to participate in society due to a resource constraint. Four distinct need areas are identified showing the necessary conditions for participating in society and performing social roles. These needs are basic goods, health, education, and leisure and social relations. Not being able to meet one of these needs due to a resource constraint prevents individuals from participating in society and performing their social roles, hence defines poverty. For example, having an unmet need in health due to a resource constraint limits ability to perform social roles and participate in society, therefore shows a state of poverty.

Then the main issue is to assess whether and how each need is met or unmet due to a resource constraint. In the previous section, components of each dimension are explored, which represent the conditions of life (goods, services and activities) required to satisfy each need, but might be lack due to a resource constraint. Then, having an enforced deprivation in one component by definition shows an unmet need in the relevant dimension. For example, if an individual cannot afford health care, she/he has unmet needs for health, or is deprived in health dimension, and hence experiences poverty.

Therefore, the key issue here is creating reliable scales to measure deprivation in components. The scales are created based on three criteria, namely face, construct and criterion validity. Yet one important shortcoming here is that, due to data limitations, only some of the identified components are possible to represent with available deprivation items. Still, as shown below, the proposed measure is an improvement to existing measures in terms its comprehensiveness.

### **5.1. *Creating scales for each component***

The scales are created using three criteria. The first is face validity, which is mainly a subjective judgement on the extent to which a scale represents the phenomenon that it purports to measure. According to this criterion, the selected items are selected to represent related components. Given the proposed definition, one important feature of the selected items should be to represent resource constraints rather than choice.

The second is construct validity, which includes empirically examining the extent to which a scale captures what it intends to measure. For this exercise, three validity indicators are used, as presented in Table 3 (the first three rows show the main indicators used, while the latter rows show the original measure out of which the three indicators are derived): i) ability to make ends meet, which is a widely used validity indicator in poverty measurement scholarship, represent individuals own assessment about the adequacy of their resources against their needs – originally a six category measure from “with great difficulty” to “very easily”, this indicator is used in a binary form, reflecting those who experience at least some difficulties making ends meet; ii) an income threshold, 120% of median, which is sometimes used as a threshold for high income; iii) a financial strain index, very similar index to the one proposed by Whelan and Maitre (2013), which includes five indicators of self-assessed financial conditions

(with a Cronbach alpha of 0.71), but used in a binary form with a threshold of zero (reporting at least one deprived financial condition).

**Table 3: Descriptives for the validity indices used for construct validity tests**

<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>	<b>N</b>
At least some difficulties making ends meet	0.61	0.49	0	1	515992
HH income below 120% median	0.65	0.48	0	1	515992
Financial strain (1+)	0.55	0.50	0	1	515992
Ability to make ends meet	3.20	1.30	1	6	515992
Financial strain index	1.71	1.27	0	5	515992
Having difficulty making ends meet	0.29	0.46	0	1	515992
Inability to pay unexpected expenses	0.37	0.48	0	1	515992
Having structural arrears	0.12	0.33	0	1	515992
Feeling heavy burden of housing cost	0.33	0.47	0	1	515992
Feeling heavy burden of debt	0.10	0.30	0	1	515992

For a scale to pass this test, a significant majority of those identified as deprived by the scale in the EU would be expected to i) report at least some difficulties making ends meet, ii) have income below 120% of median income, and iii) report at least one financial strain condition. The level of “significant majority” is chosen to be ideally 90% or minimum 80%. This choice is relatively arbitrary, yet could be regarded as justified as it only gives limited margin of error to the identified scales, which are inevitably restricted given data limitations.

The third is criterion validity, which is an empirical examination of certain abilities that are expected to be reflected by a scale. The main test for this criterion is that a component deprivation cannot be experienced by the majority of a population. Deprivation

represents an observable disadvantage relative to society an individual belongs (Townsend, 1987). Then, by definition, the rate of deprivation for a specific component should not exceed half of the population.

Based on these three criteria, the selected items and constructed scales are presented in Table 4. Regarding face validity, the first issue is that there are no suitable indicators for many identified components (e.g. healthy diet and living style). Secondly, some items do not represent resource constraints, for example in harmful environment, habitancy and housing facilities scales. To overcome this problem, either scales are supported by another subjective variable specifically related to resource constraints (e.g. reporting heavy burden of housing cost), or a threshold is applied on the number of deprivations to be counted as deprived for a component (e.g. housing facilities scale).<sup>60</sup>

Regarding construct validity, the results for each scale are presented in Appendix (Table A4). For all scales, at least 80% (and commonly above 85%) of those identified as deprived report at least some difficulties making ends meet, have income above 120% of median, and reports at least one financial strain. The only exception is the scale for harmful environment which is still kept in the measure due to low number of items in the health dimension.

Regarding criterion validity, the rates for scale are presented in Appendix (Table A5). Two problems are present. First, deprivation rates exceed 50% for leisure activities in Bulgaria, Estonia, Greece, Hungary, Latvia, Poland, Portugal, Romania and Slovakia, and for social activities in Bulgaria and Romania. Secondly, in Bulgaria, around 70% of the population is deprived in fuel and clothing components. These problems possibly

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<sup>60</sup> One last exception is the working space item used in the education goods scale; yet this type of deprivation can be assumed to be avoided by households if they could do so.

show some overestimation (Type I error) and might be related to three aforementioned issues about data: i) these activities are not part of common living patterns in these countries, hence their relationship to poverty is rather weak compared to more affluent countries (*cross-cultural equivalence*); ii) the items used in these scales suffer from significant measurement error due to the misunderstandings in the deprivation or affordability questions (*reporting error*); iii) the deprivation in these items are partly related to preferences (*behavioral choice*).

These problems cannot be solved by applying, for example, an ad hoc threshold in the leisure activities scale, as such practice while removing some Type I error for these countries might include some Type II error for more affluent countries. Similarly, removing these scales from the measure might result in loss of information, especially in more affluent countries, where these types of deprivation provides a significant source for the limited variance in deprivation. To an extent, consistent poverty approach combine income and deprivation measures to work out some of these practical problems. However, while combining the two measures can exclude some Type I error (wrongly identifying people in poverty), such practice might also include some Type II error (missing people in poverty), since by applying a dual criteria, consistent poverty measures focus only on more severe poverty cases (may be called extreme poverty). Indeed, Maitre et al. (2013: 22) consider their consistent poverty measure primarily for “distinguishing a sub-set within that [target] population which merits priority in framing anti-poverty policy”.<sup>61</sup> Another option is to use an adjustment strategy based on income and financial strain, which is the matter of next section.

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<sup>61</sup> Still a consistent poverty measure with the proposed index is constructed and compared to the consistent poverty measure of Maitre et al. (2013) – see conclusion and Supplementary Material.

**Table 4: Description of the measure – dimensions, components and related scales**

Dimensions	Components	Scales for each component
Basic goods	Food Clothing Habitancy Fuel Housing facilities	<p><b>Food</b> - Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. meal with meat every second day (M)</li> <li>ii. fresh fruit and vegetables every other day (C)</li> <li>iii. three meals a day (C)</li> </ul> <p><b>Clothing</b> - Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. replacing worn-out clothes (M)</li> <li>ii. two properly fitting shoes (M)</li> </ul> <p><b>Habitancy</b> - Being deprived of at least one of the following AND reporting heavy burden of housing cost:</p> <ul style="list-style-type: none"> <li>i. forced to leave house due to eviction, distraint or financial difficulties; (H)</li> <li>ii. having arrears for rent or mortgage (H)</li> </ul> <p><b>Fuel</b> - Being deprived of at least one of the following:</p> <ul style="list-style-type: none"> <li>i. ability to afford keeping home adequately warm (H)</li> <li>ii. having arrears for utility bills (H)</li> </ul> <p><b>Housing facilities</b> - Being deprived of at least two of the following:</p> <ul style="list-style-type: none"> <li>i. leaking roof, damp walls/floors/foundations, or rot in windows/floor (H)</li> <li>ii. shortage of space in dwelling (H)</li> <li>iii. ability to afford replacing worn-out furniture (e.g. chairs, tables etc.) (H)</li> </ul>
Health	Health care access Harmful environment	<p><b>Health care access</b> – Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. medical examination or treatment during last 12 months (M)</li> <li>ii. dental examination or treatment during the last 12 months (M)</li> </ul> <p><b>Harmful environment</b> – Being deprived of at least four of the following:</p> <ul style="list-style-type: none"> <li>i. noise from neighbors or from street (H)</li> <li>ii. pollution, grime or other environmental problems in local area (H)</li> <li>iii. crime, violence and vandalism in the area (H)</li> <li>iv. frequently litter lying around the neighborhood (H)</li> <li>v. frequently damaged public amenities in the neighborhood (H)</li> <li>vi. outdoor space in the neighborhood where children can play safely (C)</li> </ul>
Education	Education goods Learning goods Information goods	<p><b>Education goods</b> – Being deprived of at least one of the following:</p> <ul style="list-style-type: none"> <li>i. ability to afford participating in school trips/event that cost money (C)</li> <li>ii. having suitable place to study / do homework at home (C)</li> </ul> <p><b>Learning goods</b> – Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. books at home suitable for children’s age (C)</li> <li>ii. outdoor leisure equipment or indoor games (C)</li> </ul> <p><b>Information goods</b> – Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. a computer (H)</li> <li>ii. internet (H)</li> </ul>
Leisure and social relationships	Leisure activities Social activities	<p><b>Leisure activities</b> – Being deprived of at least two of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. regularly participating in a leisure activity such as sport, cinema, concert etc. for adults; swimming, playing an instrument for child (M)</li> <li>ii. spending a small amount of money each week on yourself (A)</li> <li>iii. going on a yearly holiday away from home at least one week (M)</li> </ul> <p><b>Social activities</b> – Being deprived of at least one of the following: Ability to afford</p> <ul style="list-style-type: none"> <li>i. getting together with friends/family for a drink/meal at least once a month (M)</li> <li>ii. celebrations on special occasions (C)</li> </ul>

**Notes:** (A) Adult items (C) Children items (H) Household items (M) Mixed – combined adult and children

## **5.2. Adjustment strategy**

In order to address the data problems described in Table 1 such as cross-cultural equivalence, behavioral choice and reporting error, a dual adjustment strategy is applied here. The idea is to use both an income poverty measure and a self-assessed financial strain measure as criteria to correct for possible error and reach more accurate identification of poverty.

The proposed adjustment strategy is a two-step process, aiming to, first, exclude those who wrongly identified as in poverty, and secondly, include those who are missed by the deprivation measure. In the first step, a household is considered as non-poor if it does not experience income poverty (60% of median) and does not report significant financial strain (reporting at most two out of five item). A similar approach is taken by Mack and Lansley (1985), but they only use an income poverty measure. Using only income poverty measure is not necessarily justified as income measures do not account for non-income resources, savings and debt, and heterogeneity of needs (e.g. health care, child care, social care, education, transportation etc.). Therefore, having income above 60% of median does not necessarily ensures a non-poverty state. By using also a self-assessed financial strain measure, which by definition includes an evaluation of overall resources and needs by the respondent, the aim is to reach a more robust adjustment strategy. Similarly, in the second step, a household is considered as in poverty if it experiences income poverty and reports significant financial strain. This adjustment aims to include those missed by the measure.

The results of this adjustment are summarized in Table 5 where poverty rates for each country are presented before and after each adjustment. As shown in Table 5, the first exclusion adjustment removed, in average for the EU, half of those previously identified

by the measure. The amount of removed cases significantly varies among countries, usually between 30% and 65% in relative terms, yet without any systematic pattern. Only in absolute terms, as expected, the amount removed by adjustment is higher in countries with higher initial poverty rate. As shown in Appendix (Table A6), after the first step of the adjustment, the problems related to criterion validity are resolved. After the adjustment, the rate of deprivation in each component in each country is below 50%.

**Table 5: Poverty rates for each country before and after each adjustment**

	Base measure	Exclusion adj.	Inclusion adj.	Absolute change	Relative change
AT	0.42	0.15	0.15	0.26	0.64
BE	0.39	0.19	0.19	0.19	0.50
BG	0.92	0.50	0.50	0.42	0.45
CY	0.64	0.43	0.44	0.20	0.31
CZ	0.54	0.19	0.19	0.35	0.65
DE	0.46	0.17	0.17	0.28	0.62
DK	0.21	0.07	0.07	0.13	0.64
EE	0.63	0.25	0.25	0.38	0.60
EL	0.65	0.34	0.34	0.31	0.47
ES	0.51	0.29	0.29	0.22	0.43
FI	0.25	0.12	0.12	0.13	0.52
FR	0.45	0.20	0.20	0.24	0.55
HU	0.80	0.42	0.42	0.38	0.48
IE	0.50	0.26	0.27	0.23	0.47
IT	0.57	0.31	0.31	0.26	0.45
LT	0.76	0.34	0.34	0.41	0.55
LU	0.28	0.14	0.14	0.14	0.49
LV	0.84	0.45	0.45	0.39	0.46
NL	0.25	0.09	0.09	0.16	0.65
PL	0.74	0.33	0.33	0.41	0.56
PT	0.73	0.28	0.28	0.44	0.61
RO	0.91	0.41	0.41	0.50	0.55
SI	0.51	0.26	0.26	0.25	0.49
SK	0.71	0.24	0.24	0.47	0.66
UK	0.44	0.20	0.20	0.24	0.54
Total	0.54	0.25	0.25	0.29	0.53

Despite the significant numbers removed by the first adjustment, the second inclusion adjustment does not seem to significantly change the numbers. This might show that the underestimation problems (Type II) such as adaptive preferences and desirability bias are not significant matters for the proposed measure, while overestimation problems (Type I) related to cross-cultural equivalence, behavioral choices and reporting error are important. Nevertheless, the adjustment strategy seems to effectively mitigate these Type I errors. In the following, this claim is examined further by testing the validity of the proposed measure.

## **6. Examining the validity of the proposed measure**

The validity of the proposed measure is examined relatively by comparing its performance to EU 2020 poverty target measure using a multinomial logistic model. The aim is to see which measures identify better the groups that are theoretically and empirically expected to be in poverty. For example, given the definition of poverty above, we would expect those with lower resources and higher needs to be more likely to experience poverty. Also, it is important to consider the country profiles of the groups identified by each measure. As shown below, despite a significant agreement between the two measures, there is still substantial amount of people identified only by one measure. The idea is to compare the group identified only by proposed measure to the group identified only by EU measure based on their resources and needs.

The EU 2020 poverty target measure and explanatory variables used in regression analyses are presented in Table 6. The EU's 2020 poverty target includes a material deprivation index, an income poverty measure and a low work-intensity measure.

Recently a 13-item material deprivation index proposed by Guio et al. (2016) is endorsed by the EU to replace the old 9-item measure (Atkinson et al., 2017). This new deprivation index is used here to construct the new EU formal poverty measure. The income poverty measure is the commonly used relative measure which defines those with household disposable incomes below 60% of median income as in poverty. The households with low work intensity are defined as those with working-age members worked less than 20% of their potential in the previous year. Being identified by either of these three measures are considered as in poverty by the EU measure.

**Table 6: The variables used in the regression analysis**

<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>	<b>N</b>
<b>Poverty measures</b>					
EU 2020 poverty target	0.26	0.44	0	1	515992
13 item index (7+ deprived items)	0.13	0.33	0	1	515992
Income poverty (60% median)	0.16	0.36	0	1	515992
Low work intensity	0.06	0.24	0	1	515992
<b>Explanatory variables</b>					
<i>Resources</i>					
HRP Social class (ESEC 5)	3.04	1.71	1	6	193639
HRP Education (ISCED)	2.07	0.77	1	3	193639
Unemployed in HH	0.10	0.31	0	1	193639
Tenant	0.18	0.38	0	1	193639
<i>Needs</i>					
Disability in HH	0.39	0.49	0	1	193639
Chronic health pr. In HH	0.46	0.50	0	1	193639
Self-rated bad health in HH	0.19	0.39	0	1	193639
Child aged 0-2 in HH	0.07	0.26	0	1	193639
Child aged 3-4 in HH	0.05	0.21	0	1	193639
Child aged 5-11 in HH	0.14	0.35	0	1	193639
Child aged 12-15 in HH	0.11	0.31	0	1	193639
Single parenthood	0.04	0.19	0	1	193639
Extended family	0.07	0.26	0	1	193639
HRP Divorced / separated	0.11	0.31	0	1	193639
HRP female	0.40	0.49	0	1	193639

The explanatory variables, which can be considered as risk factors, represent either resources or needs. For example, social class and education are long argued to be good determinants of long-term command over resources (Hauser & Warren, 1997; Bollen et al., 2007). Others such as unemployment and tenancy are more immediate indicators of economic conditions. Given the model includes these resources variables, variables such as chronic health, disability or self-reported bad health problem in the household show the effect of having extra needs and costs for health care, while having children aged 3-4, 5-11, 12-15 in the household reflect the needs and costs related to child bearing such as those related to education. Also these variables also represent extra care responsibilities in the household which might also result in limited earning potential especially for women (Beduk, 2016). In addition, other demographic characteristics such as single parenthood, extended family and marital status proxy experiences of specific life events, where the balance of resources and needs tend to be difficult to sustain. Also country fixed effects are included to examine the country profiles captured by each measure. Others such as age and gender of the household reference person are included as controls.

As shown in Table A7 in Appendix, missing data for poverty measures are very low (below 0.4%) yet with the exception of 13-item Guio index and EU 2020 poverty target having around 1.7% of the total population, which corresponds to missing data in deprivation indicators, hence excluded from the analysis. As shown in Table A8 in Appendix, missing rate for explanatory factors are also very low, where it is highest for education (2%) and social class (1.3%); still in total, the missing rate for all variables corresponds to 3.6% of the household sample. The missing in social class is mainly due to Malta, where the missing rate is %21. Also, in Malta, the social class variable has a

coding problem as the country seems to have only salariat, intermediate employee and never worked. Therefore, Malta is also excluded from the analysis.

The unit of analysis for the regression analyses is household using information of household reference person (similar to previous analogous analyses, for example by Whelan & Maître (2012)). This is because most of the deprivation indicators are collected at the household level, which in an individual level analysis might cause clustering at the household level. Also, using household reference person information allows including individual level explanatory factors such as social class and education. The analysis is run for the whole sample with country fixed effects, which includes 25 European countries excluding Sweden and Malta.

### **6.1. Comparing to EU 2020 poverty target**

The results for the proposed measure and the EU 2020 poverty target with the recently endorsed 13-item index are presented at Table 7. The average rate for the proposed measure is 25% and for the EU 2020 target is 24%. The variances and ranges are similar in both measures.

Compared to the new EU 2020 measure, the proposed poverty measure has usually lower rates in more affluent countries such as Denmark, Finland and Netherlands, and similar or higher rates in less affluent countries such as Hungary and Latvia (except Bulgaria and Romania).

The agreement between the two measures is very high, in average around 86%. The amount of agreement varies across countries with a relatively low variance – lowest in Cyprus with 70% and highest in Germany with 91%. The agreement between seems to

be lower for less affluent countries, possibly due to the fact that deprivation are much more widespread in less affluent countries.

**Table 7: Proposed measure vs. EU 2020 poverty target – mismatch**

Country	Proposed measure	New EU 2020	Agreement	Only proposed	Only EU 2020
AT	0.15	0.17	0.90	0.04	0.06
BE	0.19	0.20	0.88	0.06	0.07
BG	0.50	0.56	0.81	0.07	0.12
CY	0.43	0.20	0.70	0.27	0.04
CZ	0.18	0.14	0.88	0.08	0.04
DE	0.17	0.21	0.91	0.03	0.06
DK	0.07	0.16	0.88	0.02	0.11
EE	0.25	0.24	0.89	0.06	0.05
EL	0.34	0.26	0.83	0.13	0.05
ES	0.29	0.23	0.81	0.12	0.07
FI	0.12	0.16	0.88	0.04	0.08
FR	0.20	0.19	0.88	0.07	0.06
HU	0.42	0.35	0.79	0.14	0.07
IE	0.27	0.25	0.83	0.09	0.08
IT	0.31	0.25	0.82	0.12	0.05
LT	0.34	0.33	0.84	0.08	0.07
LU	0.14	0.18	0.90	0.03	0.07
LV	0.45	0.42	0.84	0.09	0.07
NL	0.09	0.15	0.90	0.02	0.08
PL	0.33	0.29	0.85	0.10	0.05
PT	0.28	0.30	0.87	0.06	0.07
RO	0.41	0.53	0.81	0.04	0.16
SI	0.26	0.17	0.83	0.13	0.04
SK	0.24	0.20	0.86	0.09	0.05
UK	0.20	0.23	0.86	0.06	0.09
Mean	0.25	0.24	0.86	0.07	0.07
Variance	0.19	0.19	0.12	0.07	0.06

Regarding disagreement, 7% of the EU population is identified only by the proposed measure and another 7% is identified only by the EU measure. The amount of disagreement varies across countries and across measures. The amount of people

identified only by the proposed measure is usually higher in less affluent countries such as Hungary and Greece, while the groups identified only by the EU measure are significantly bigger in more affluent countries such as Denmark, Finland, Luxembourg (again Romania and Bulgaria are exceptions).

The question is which measure identifies more accurately the groups that are expected to be in poverty given their resources and needs. To examine this, a multinomial logit model is applied. The dependent variable is constructed based on four categories: i) not identified by both measures (none), ii) identified both by the proposed and the EU measure (both); iii) identified only by the proposed measure (only deprived), iv) identified only by the EU measure (only EU). The base outcome category is chosen as those identified only by the EU measure. The idea is to compare the profiles of those identified only by the EU measure to those identified only by the deprivation measure based on the risk factors. The results for main explanatory variables are presented in Table 8. The coefficients show relative risk ratios. In addition the main explanatory variables, household reference person age and country fixed effects are also added to the model.

In the first column, the comparison is between those identified only by the EU measure and those not identified. As seen by the significance of coefficients, the group captured only by EU measure is significantly different than those not identified. As would be expected, those identified only by the EU measure in general tend to have lower resources and higher needs compared to those not identified. For example, those not identified are significantly less likely to have lower social classes and education, and to have health problems in the household. Yet there are two interesting results. First, for those who have at least a child younger than twelve and those who have at least one member with a chronic health problem in the household are equally likely to be either not

identified or identified only by the EU measure. Secondly, those living extended family households are more likely to be not identified than being identified only by the EU measure.

**Table 8: Comparing the proposed measure and the EU 2020 poverty target measure based on identified risk factors – relative risk ratios**

Multinomial logit / Base outcome = New EU 2020 only			
	None	Both	Proposed only
<b>Resource indicators</b>			
HRP Social class ( <i>ref=Salariat</i> )			
Intermediate	0.888*	1.381***	1.384***
Small self-emp.	0.387***	2.002***	0.624***
Non-manual labor	0.670***	1.765***	1.285**
Manual labor	0.567***	1.909***	1.185**
Never worked	0.202***	1.525***	0.389***
HRP Education ( <i>ref=Third level</i> )			
Upper secondary	0.768***	1.217***	1.117
Low second/Primary/Pre	0.588***	1.731***	1.100
Unemployed in HH	0.440***	2.164***	1.052
Tenant	0.686***	1.949***	1.528***
<b>Need indicators</b>			
Disability in HH	0.794***	1.174***	1.086
Chronic health pr. in HH	0.946	0.982	1.049
Bad subj. health	0.736***	1.529***	1.249***
Child aged 0-2 in HH	0.901	1.287**	1.179
Child aged 3-4 in HH	1.059	1.276**	1.240*
Child aged 5-11 in HH	0.986	1.313***	1.342***
Child aged 12-15 in HH	1.129*	1.634***	1.488***
Single parent household	0.452***	1.096	0.809*
Extended family	1.429***	1.030	1.429***
HRP divorced/separated	0.750***	1.376***	1.197**
HRP Female	0.782***	1.231***	1.162***

In the second column, the comparison is between those identified only by the EU measure and those identified by both the EU and the proposed measure. Again as

expected, those identified by both measures tend to have lower resources and higher needs. For example, they are more likely to be in lower classes, have at least one unemployed person or a person with health problems or children in the household. Again, there are two exceptions. Those who have at least one person with a chronic problem in the household and those who have an extended family household are equally likely to be identified by only the EU measure or by both measures.

In the third column, the comparison is between those identified only by the EU measure and those identified only by the proposed measure. In general, the results show that those identified by the proposed measure are more likely to have lower resources and higher needs. Starting with social class, those in the intermediate, non-manual and manual classes (compared to salariat class) are significantly more likely to be identified only by the proposed measure than only by the EU measure. On the other hand, small self-employed and never worked are significantly less likely to be identified only by the proposed measure compared to the EU measure. This might be related to i) the specific situation of self-employed in terms of cash income, and ii) the heterogeneous composition of the never worked groups which includes individuals with different economic statuses such as long-term unemployed, students, domestic workers and other inactive. Both of these might specifically be captured by the income poverty and low work intensity components of the EU measure. Regarding other resource indicators, those who are tenant are also significantly more likely to be captured only by the proposed measure. The differences are even greater on the needs side. The households with health problems, with children aged 3-15, those living in extended family households, with a divorced or separated, or a female household reference person are also more likely to be captured only by the proposed measure. Only single parenthood is more likely to be captured by the EU compared to the proposed measure.

In addition to resource and need profiles, one can also examine, controlling for the individual factors, from which countries each measure is more likely to capture people. In Table 9, the coefficients of the country fixed effect from the model is presented. The estimation is from the same model presented above. The country coefficients are useful to examine to see the location of the groups picked up by each measure compared to the other.

**Table 9: Country profiles captured by each measure**

Multinomial logit / Base outcome = New EU 2020 only			
	None	Both	Proposed only
<b>Country</b> ( <i>ref=AT</i> )			
BE	0.796**	1.017	1.476**
BG	0.240***	3.207***	1.484**
CY	1.116	4.301***	17.141***
CZ	1.614***	1.763***	4.277***
DE	0.911	1.726***	0.783
DK	0.550***	0.276***	0.233***
EE	0.866	2.721***	2.012***
EL	1.637***	3.731***	10.101***
ES	0.999	1.403***	4.386***
FI	0.681***	0.553***	0.759*
FR	1.195*	1.266*	2.203***
HU	0.614***	2.542***	4.665***
IE	0.845	1.213	2.502***
IT	1.281***	2.110***	6.164***
LT	0.604***	2.943***	2.846***
LU	1.059	0.825	0.833
LV	0.588***	4.139***	2.856***
NL	0.813*	0.505***	0.531***
PL	0.977	3.471***	5.051***
PT	1.119	1.455**	1.869***
RO	0.249***	2.042***	0.855
SI	1.051	2.623***	5.725***
SK	1.183	2.343***	4.281***
UK	0.556***	0.868	1.094

Starting from the second column, where those identified by both measures are compared to those identified only by the EU measure; almost in all countries, it is significantly more likely to be identified by both measures than being identified only by the EU measure. The only exceptions are Denmark, Finland and Netherlands. Individual living in these countries are more likely to be identified by the EU measure than being identified by both measures. Similarly, as shown in the third column, the proposed measure is significantly less likely to identify people from Denmark, Finland, and Netherlands compared to the EU measure. For example, compared to those identified only by the EU measure, those identified only by the proposed measure are around 8 times more likely to be in Hungary, 7.5 times more likely to be in Greece, and 4.5 times more likely to be in Bulgaria or Hungary (relative to being in Austria).

These findings show that i) the proposed measure is more likely to capture disadvantaged risk groups who tend to have lower resources and extra individual and household needs; and, ii) the proposed measure is more likely to capture individuals from less affluent countries compared to the EU measure. All these support the claim that the proposed measure is more likely to identify the people in poverty than the EU poverty target measure.

## **7. Conclusion**

This paper focused on constructing a multidimensional deprivation measure of poverty that can possibly mitigate given available data the problems of existing deprivation scales. It is argued that deprivation measure can alone be used to assess poverty, both conceptually and empirically, yet with certain improvements. The paper focused on three conceptual problems of existing measures such as missing dimensions, data-driven specification and neglecting multidimensionality; and three practical data issues such as

cross-cultural equivalence, behavioral choice and reporting error. These problems, it is argued, can directly cause measurement errors, either underestimation (Type II error) or overestimation (Type I error).

The proposed measure has four distinct design features compared to the existing ones. First, it is a concept-led measure, where measurement design is primarily determined by the definition of poverty. To do this, a substantial part of the analysis is devoted to elaborating the meaning of poverty defined within the relative deprivation framework. Through this conceptual analysis, the dimensions are conceptually derived prior to measurement drawing on the elaborated definition of poverty and related empirical evidence. Dimensions of poverty are defined as the needs that are necessary for performing social roles and social participation, and the conditions of life required to satisfy these needs which might be lack due to resource constraints are defined as the components of needs.

Secondly, the measure is more comprehensive compared to its existing counterparts including dimensions such as needs related to health and education. Despite this improvement, the measure is still limited given available data, since i) other possible dimensions such as needs related to caring, and personal and political security are missing, ii) the scales created for the components are restricted and includes only a small number of indicators; and iii) some components of some dimensions could be not measured (e.g. those related to health-promoting goods, and health diet and living style).

Thirdly, as Bourguignon & Chakravarty (2003) put it, it is a “truly multidimensional measure”, where each dimension is evaluated separately and then aggregated with a zero threshold to reach the total poverty measure. In other words, being deprived in at least one dimension qualifies an individual for being counted as in poverty. This choice is

again derived from the definition of poverty. Not being able to meet an identified need due to a resource constraint conduces to an inability to perform social roles and participating in society. As shown in supplementary material, evaluating each dimensions separately improves the accuracy of measurement in multiple ways. The analysis has shown that a significant group of people is identified only by one dimension whom are generally missed by the existing deprivation scales due to their unidimensional design. Also, the groups captured by each dimension have distinct characteristics reflecting dimension-specific deprivation conditions. For example, those with long-term health problems are more likely to be captured by the health dimension which considers extra costs and needs related to health care. Similarly, those households with children are more likely to be captured by education dimension which considers enforced deprivations of educational goods and services. In other words, accounting for multidimensionality helps to capture different experiences of poverty which is otherwise neglected when different types of poverty is collapsed into one scale.

Lastly, the measure is adjusted using dual criteria of income poverty and self-assessed financial strain. This adjustment strategy is applied mainly to correct for possible underestimation or overestimation due to suspicions about the quality of data, regarding its equivalence across countries, its robustness to differences in behavioral choices and reporting error. The results of the adjustment shows that the main issue is related to overestimation of poverty numbers either due to cross-cultural equivalence (e.g. meaning of holiday for social participation) or reporting error (misunderstandings of the deprivation or affordability questions).

The validity of the proposed measure is assessed against the EU's 2020 poverty target measure using a multinomial logistic model. The results shows that the proposed

measure is more likely to capture those with needs (e.g. health problems, and those related to child bearing, or specific life event situations such as divorce) and lower resources (e.g. social class, house ownership), and also much less likely identify people from affluent countries such as Denmark, Finland and Netherlands, and more likely to identify people from less affluent countries such as Greece and Hungary compared to the EU measure.

This measure is designed primarily for the identification of people in poverty, yet can be developed further using Alkire-Foster method to create a poverty index that can account both incidence and intensity of poverty. Also, if the aim is to focus on the most disadvantaged, the unadjusted multidimensional measure can be combined with an income poverty measure to construct a consistent poverty measure. As shown in Supplementary Material, such a consistent poverty measure, compared to the one proposed by Whelan et al. (2013), captures an additional group who is predominantly working class or never worked, and more likely to report difficulties making ends meet and financial strain compared to the EU average.

Despite providing some solutions to the proposed problem, the applied adjustment strategy is an ad hoc, and assessing its effectiveness is rather difficult. Further analysis is required to question the issues related to the validity of deprivation data, especially regarding overestimation (Type I error) to reach more robust poverty measures constructed based on deprivation indicators. Especially, more attention on the issues related to cross-cultural equivalence are of utmost importance.

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## 8. Appendix

**Table A1: Adult, household and child deprivation indicators**

<b>Adult indicators</b>	<b>Description</b>	<b>Unit</b>	<b>Mode of collection</b>	<b>Enforced criterion</b>
Acloth	Replace worn-out clothes by some new (not second-hand) ones	All adult (16+) HH members	Personal or HH resp.	✓
Ashoes	Two pairs of properly fitting shoes (including a pair of all-weather shoes)	All adult (16+) HH members	Personal or HH resp.	✓
Ameet	Meeting friends/family for a drink/meal at least once a month	All adult (16+) HH members	Personal or HH resp.	✓
Aleisure	Regularly participate in a leisure activity e.g. sport, cinema, concert	All adult (16+) HH members	Personal or HH resp.	✓
Asmoney	Spend a small amount of money each week on yourself	All adult (16+) HH members	Personal or HH resp.	✓
Aunmet	Unmet need for medical examination or treatment	Selected resp. or all adult(16+)	Personal or HH resp.	✓
Adentist	Unmet need for dental examination or treatment	Selected resp. or all adult(16+)	Personal or HH resp.	✓
<b>Household indicators</b>	<b>Description</b>	<b>Unit</b>	<b>Mode of collection</b>	<b>Enforced criterion</b>
Hmeat	A meal with meat, chicken or fish (or vegetarian equiv.) at least once a day	Household	Household respondent	✓
Hwarm	Ability to keep home adequately warm	Household	Household respondent	✓
Hholiday	One week annual holiday away from home	Household	Household respondent	✓
Hunexp	Ability to face unexpected financial expenses (e.g. surgery, funeral, major repair in the house, replacement of durables, car etc.)	Household	Household respondent	✓
Hrefurnish	Replace worn-out furniture	Household	Household respondent	✓
Hnet	Internet connection	Household	Household respondent	✓
HPC	Computer	Household	Household respondent	✓
Hcar	Car	Household	Household respondent	✓
Hmortgage	Arrears on mortgage or rent payments	Household	Household respondent	✓
Hutility	Arrears on utility bills	Household	Household respondent	✓
Hloan	Arrears on hire purchase instalments or loan payments	Household	Household respondent	✓
Hroof	Leaking roof, damp walls/floors/foundation, or rot in window frames or floor	Household	Household respondent	X
Hspace	Shortage of space in dwelling (subj.)	Household	Household respondent	X
Hhoc	A heavy or slight financial burden of the total housing cost	Household	Household respondent	X
Hevict	Forced to leave dwelling due to eviction or distraint or for financial difficulties	Household	Household respondent	✓

Hnoise	Noise from neighbors or from street	Household	Household respondent	X
Hpollution	Pollution, grime or other environmental problems in the local neighborhood	Household	Household respondent	X
Hcrime	Crime, violence and vandalism in the area	Household	Household respondent	X
Hlitter	Litter lying around the neighborhood	Household	Household respondent	X
Hdamaged	Damaged public amenities in the neighborhood	Household	Household respondent	X

<b>Child indicators</b>	<b>Description</b>	<b>Unit</b>	<b>Mode of collection</b>	<b>Enforced criterion</b>
CHcloth	Some new (not second-hand) ones	Child aged 1-16	Household respondent	✓
CHshoes	Two pairs of properly fitting shoes (including a pair of all-weather shoes)	Child aged 1-16	Household respondent	✓
CHfruit	Fresh fruit and vegetables once a day	Child aged 1-16	Household respondent	✓
CHthmeals	Three meals a day	Child aged 1-16	Household respondent	✓
CHmeat	One meal with meat, chicken or fish (or vegetarian equivalent) at least once a day	Child aged 1-16	Household respondent	✓
CHbooks	Books at home suitable for their age	Child aged 1-16	Household respondent	✓
CHtoys	Outdoor leisure equipment (bicycle, roller skates, etc.)	Child aged 1-16	Household respondent	✓
CHgames	Indoor games (educational baby toys, building blocks, board games, PC games etc.)	Child aged 1-16	Household respondent	✓
CHleisure	Regular leisure activity (swimming, playing an instrument, riding a bicycle etc.)	Child aged 1-16	Household respondent	✓
CHceleb	Celebrations on special occasions (birthdays, name days, religious events, etc.)	Child aged 1-16	Household respondent	✓
CHmeet	Invite friends round to play and eat from time to time	Child aged 1-16	Household respondent	✓
CHtrips	Participate in school trips and school events that cost money	Child aged 1-16	Household respondent	✓
CHworkspace	Suitable place to study or do homework	Child aged 1-16	Household respondent	X
CHoutplay	Outdoor space in the neighborhood where children can play safely	Child aged 1-16	Household respondent	X
CHholiday	One week annual holiday away from home	Child aged 1-16	Household respondent	✓
CHunmet	Unmet need for medical examination or treatment	Child aged 1-16	Household respondent	✓
CHdentist	Unmet need for dental examination or treatment	Child aged 1-16	Household respondent	✓

**Table A2: Missing data and descriptives for total individual sample**

Variable	# of missing	Total sample	% of missing	Mean	Sd	Min	Max
Hcloth	606	525,154	0.10	0.15	0.35	0	1
Hshoes	589	525,154	0.10	0.04	0.20	0	1
Hmeet	612	525,154	0.10	0.16	0.37	0	1
Hleisure	572	525,154	0.10	0.22	0.41	0	1
Hsmoney	682	525,154	0.10	0.22	0.41	0	1
Hunmet	531	525,154	0.10	0.03	0.18	0	1
Hdentist	481	525,154	0.10	0.07	0.25	0	1
CHcloth	1,169	525,154	0.20	0.03	0.17	0	1
CHshoes	1,161	525,154	0.20	0.02	0.13	0	1
CHfruit	1,172	525,154	0.20	0.02	0.14	0	1
CHthmeals	1,159	525,154	0.20	0.00	0.07	0	1
CHmeat	1,151	525,154	0.20	0.02	0.14	0	1
CHbooks	1,215	525,154	0.20	0.02	0.15	0	1
CHtoys	1,149	525,154	0.20	0.03	0.17	0	1
CHgames	1,465	525,154	0.30	0.02	0.15	0	1
CHleisure	1,886	525,154	0.40	0.05	0.21	0	1
CHceleb	1,418	525,154	0.30	0.02	0.16	0	1
CHmeet	1,680	525,154	0.30	0.03	0.17	0	1
CHtrips	1,125	525,154	0.20	0.03	0.16	0	1
CHworkspace	1,421	525,154	0.30	0.02	0.15	0	1
CHholiday	2,111	525,154	0.40	0.07	0.26	0	1
CHunmet	11	525,154	0.00	0.00	0.07	0	1
CHdentist	54	525,154	0.00	0.01	0.08	0	1
Hmeat	191	525,154	0.00	0.11	0.31	0	1
Hwarm	245	525,154	0.00	0.10	0.30	0	1
Hholiday	383	525,154	0.10	0.40	0.49	0	1
Hunexp	683	525,154	0.10	0.37	0.48	0	1
Hrefurnish	596	525,154	0.10	0.32	0.47	0	1
Hnet	200	525,154	0.00	0.09	0.29	0	1
HPC	400	525,154	0.10	0.17	0.38	0	1
Hcar	198	525,154	0.00	0.07	0.26	0	1
Hmortgage	423	525,154	0.10	0.03	0.18	0	1
Hutility	363	525,154	0.10	0.10	0.30	0	1
Hloan	345	525,154	0.10	0.04	0.19	0	1
Hroof	168	525,154	0.00	0.00	0.06	0	1
Hspace	210	525,154	0.00	0.12	0.33	0	1
Hhoc	721	525,154	0.10	0.83	0.38	0	1
Hevict	1,058	525,154	0.20	0.02	0.13	0	1
Total missing	8703	525,154	1.70				

*Notes: The adult items are distributed to household members; if an adult is deprived, the whole household is taken as deprived.*

**Table A3: Missing data for deprivation indicators for each country**

<b>Country</b>	<b># of missing</b>	<b>Total sample</b>	<b>% of missing</b>
AT	295	13,610	2.20
BE	455	14,721	3.10
BG	23	15,047	0.20
CY	0	9,283	0.00
CZ	7	23,302	0.00
DE	1,298	28,368	4.60
DK	703	15,025	4.70
EE	322	13,542	2.40
EL	0	18,035	0.00
ES	524	36,865	1.40
FI	607	25,157	2.40
FR	939	25,611	3.70
HU	557	25,053	2.20
IE	443	12,641	3.50
IT	0	51,196	0.00
LT	12	12,852	0.10
LU	459	11,406	4.00
LV	10	14,403	0.10
NL	616	23,687	2.60
PL	5	38,541	0.00
PT	335	13,013	2.60
RO	0	18,703	0.00
SI	35	29,576	0.10
SK	268	16,137	1.70
UK	790	19,380	4.10
Total	8,703	525,154	1.70
SE	8,387	18,441	45.50

**Table A4: Testing construct validity of each scale – percentages among those identified by each measure reporting some difficulties making ends meet, having income below 120% of median and reporting at least one financial strain**

<b>Components</b>	<b>At least some difficulties making ends meet</b>	<b>Having income below 120% of median</b>	<b>Reporting at least one financial strain</b>
Food	95	89	93
Clothing	97	88	100
Habitancy	94	82	95
Fuel	95	86	92
Housing facilities	91	83	87
Health care	95	83	91
Harmful environment	79	70	76
Education goods	90	90	89
Learning goods	98	92	93
Information goods	94	89	90
Leisure activities	88	81	83
Social activities	92	84	89

**Table A5: Rates for each scale for each country**

Country	Food	Clothing	Habitancy	Fuel	Housing facilities	Health care	Harmful environment	Education goods	Learning goods	Information goods	Leisure activities	Social activities
AT	0.10	0.09	0.02	0.07	0.10	0.01	0.03	0.02	0.01	0.05	0.34	0.10
BE	0.05	0.08	0.02	0.09	0.09	0.02	0.05	0.03	0.02	0.06	0.31	0.12
BG	0.42	<b>0.68</b>	0.03	<b>0.70</b>	0.37	0.26	0.13	0.12	0.18	0.26	<b>0.81</b>	<b>0.60</b>
CY	0.05	0.12	0.04	0.30	0.29	0.13	0.04	0.03	0.02	0.06	0.49	0.08
CZ	0.11	0.09	0.03	0.08	0.15	0.01	0.08	0.02	0.02	0.08	0.44	0.05
DE	0.10	0.10	0.02	0.08	0.10	0.05	0.04	0.03	0.01	0.07	0.35	0.27
DK	0.01	0.06	0.01	0.04	0.05	0.02	0.01	0.01	0.01	0.02	0.13	0.02
EE	0.10	0.13	0.01	0.11	0.21	0.08	0.02	0.03	0.03	0.07	<b>0.54</b>	0.12
EL	0.09	0.13	0.04	0.27	0.24	0.14	0.07	0.06	0.04	0.14	<b>0.53</b>	0.11
ES	0.02	0.05	0.05	0.10	0.15	0.07	0.03	0.02	0.01	0.11	0.42	0.10
FI	0.03	0.07	0.03	0.08	0.04	0.01	0.01	0.01	0.00	0.03	0.16	0.02
FR	0.08	0.12	0.04	0.11	0.12	0.08	0.03	0.03	0.01	0.06	0.36	0.08
HU	0.29	0.35	0.03	0.25	0.19	0.07	0.06	0.03	0.08	0.15	<b>0.73</b>	0.42
IE	0.03	0.06	0.05	0.13	0.09	0.06	0.04	0.02	0.01	0.08	0.44	0.10
IT	0.07	0.11	0.03	0.18	0.07	0.14	0.06	0.05	0.03	0.05	0.50	0.14
LT	0.21	0.29	0.01	0.29	0.24	0.06	0.05	0.04	0.05	0.12	<b>0.65</b>	0.32
LU	0.02	0.06	0.02	0.02	0.12	0.01	0.02	0.05	0.01	0.02	0.18	0.06
LV	0.24	0.41	0.04	0.28	0.33	0.25	0.08	0.04	0.09	0.10	<b>0.76</b>	0.32
NL	0.02	0.03	0.01	0.03	0.09	0.01	0.05	0.02	0.00	0.01	0.17	0.02
PL	0.19	0.20	0.01	0.25	0.21	0.11	0.04	0.05	0.06	0.15	<b>0.68</b>	0.20
PT	0.05	0.25	0.04	0.30	0.22	0.22	0.06	0.08	0.07	0.14	<b>0.67</b>	0.28
RO	0.30	0.47	0.01	0.37	0.33	0.27	0.07	0.23	0.29	0.28	<b>0.87</b>	<b>0.68</b>
SI	0.11	0.15	0.02	0.20	0.21	0.00	0.03	0.02	0.01	0.05	0.37	0.07
SK	0.25	0.17	0.04	0.14	0.11	0.03	0.10	0.04	0.05	0.13	<b>0.61</b>	0.15
UK	0.04	0.08	0.02	0.08	0.10	0.01	0.07	0.02	0.01	0.04	0.36	0.12
Total	0.10	0.14	0.03	0.15	0.14	0.08	0.05	0.04	0.04	0.09	0.45	0.18

Notes: *Weighted*

**Table A6: Rates of each scale for each country after adjustment**

Country	Food	Clothing	Habitancy	Fuel	Housing facilities	Health care	Harmful environment	Education goods	Learning goods	Information goods	Leisure activities	Social activities
AT	0.06	0.05	0.02	0.04	0.05	0.01	0.01	0.01	0.01	0.03	0.14	0.06
BE	0.04	0.07	0.02	0.07	0.06	0.02	0.02	0.02	0.02	0.04	0.17	0.08
BG	0.35	0.44	0.03	0.45	0.24	0.19	0.08	0.09	0.14	0.19	0.49	0.39
CY	0.04	0.09	0.04	0.24	0.22	0.12	0.02	0.03	0.02	0.05	0.36	0.07
CZ	0.06	0.06	0.03	0.05	0.06	0.01	0.02	0.02	0.02	0.05	0.17	0.03
DE	0.06	0.06	0.01	0.05	0.06	0.03	0.02	0.01	0.01	0.04	0.16	0.12
DK	0.01	0.03	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.06	0.01
EE	0.07	0.09	0.01	0.08	0.10	0.05	0.01	0.01	0.02	0.04	0.24	0.07
EL	0.07	0.10	0.04	0.20	0.16	0.10	0.03	0.04	0.03	0.09	0.30	0.09
ES	0.01	0.04	0.05	0.08	0.10	0.05	0.02	0.02	0.01	0.08	0.26	0.08
FI	0.02	0.04	0.02	0.05	0.02	0.00	0.00	0.00	0.00	0.02	0.09	0.01
FR	0.06	0.08	0.04	0.09	0.07	0.04	0.02	0.02	0.01	0.04	0.18	0.06
HU	0.21	0.25	0.03	0.21	0.14	0.06	0.04	0.03	0.07	0.11	0.40	0.28
IE	0.02	0.05	0.05	0.10	0.06	0.03	0.02	0.02	0.01	0.06	0.25	0.08
IT	0.06	0.09	0.03	0.15	0.05	0.10	0.03	0.04	0.03	0.04	0.29	0.10
LT	0.14	0.19	0.01	0.17	0.14	0.04	0.02	0.03	0.04	0.09	0.32	0.20
LU	0.01	0.05	0.02	0.02	0.07	0.01	0.01	0.02	0.01	0.01	0.11	0.05
LV	0.20	0.29	0.04	0.23	0.20	0.19	0.05	0.04	0.08	0.08	0.43	0.23
NL	0.01	0.02	0.01	0.02	0.04	0.01	0.01	0.01	0.00	0.01	0.07	0.02
PL	0.13	0.14	0.01	0.17	0.13	0.07	0.02	0.04	0.05	0.09	0.32	0.14
PT	0.03	0.16	0.04	0.15	0.12	0.13	0.02	0.05	0.05	0.08	0.28	0.16
RO	0.20	0.28	0.00	0.25	0.21	0.17	0.03	0.16	0.19	0.17	0.41	0.36
SI	0.08	0.11	0.02	0.14	0.13	0.00	0.02	0.01	0.00	0.03	0.22	0.05
SK	0.14	0.10	0.04	0.08	0.07	0.02	0.04	0.03	0.04	0.08	0.23	0.08
UK	0.03	0.06	0.02	0.05	0.05	0.00	0.03	0.01	0.01	0.03	0.19	0.08
Total	0.07	0.09	0.02	0.11	0.08	0.05	0.02	0.03	0.03	0.06	0.23	0.11

**Table A7: Missing data and descriptives of poverty and validity measures for the whole sample**

	# of missing	Total sample	% of missing	mean	sd	min	max
<b>Poverty measures</b>							
EU 2020 poverty target	8,863	525,154	1.69	0.26	0.44	0	1
13 item index (7+ deprived items)	8,703	525,154	1.66	0.13	0.33	0	1
Income poverty (60% median)	0	525,154	0.00	0.16	0.36	0	1
Low work intensity	160	525,154	0.03	0.06	0.24	0	1
<b>Validity measures</b>							
Ability to make ends meet	440	525,154	0.08	3.20	1.30	1	6
HH income below 120% median	0	525,154	0.00	0.65	0.48	0	1
Financial strain index	2,044	525,154	0.39	1.71	1.27	0	5
Having difficulty making ends meet	440	525,154	0.08	0.29	0.46	0	1
Inability to pay unexpected expenses	683	525,154	0.13	0.37	0.48	0	1
Having structural arrears	631	525,154	0.12	0.12	0.33	0	1
Feeling heavy burden of housing cost	721	525,154	0.14	0.83	0.38	0	1
Feeling heavy burden of debt	202	525,154	0.04	0.10	0.30	0	1
<b>Total</b>	<b>9,162</b>	<b>525,154</b>	<b>1.74</b>				

**Table A8: Missing data and descriptives of explanatory variables for household reference person**

	# of missing	Total sample	% of missing	mean	sd	min	max
<i>Resources</i>							
HRP Social class (ESEC)	2,722	204,169	1.33	3.04	1.71	1	6
HRP Education (ISCED)	4,114	204,169	2.01	2.07	0.77	1	3
Unemployed in HH	0	204,169	0.00	0.10	0.31	0	1
Tenant	8	204,169	0.00	0.18	0.38	0	1
<i>Needs</i>							
Disability in HH	840	204,169	0.41	0.39	0.49	0	1
Chronic health pr. In HH	754	204,169	0.37	0.46	0.50	0	1
Self-rated bad health in HH	627	204,169	0.31	0.19	0.39	0	1
Child aged 0-2 in HH	0	204,169	0.00	0.07	0.26	0	1
Child aged 3-4 in HH	0	204,169	0.00	0.05	0.21	0	1
Child aged 5-11 in HH	0	204,169	0.00	0.14	0.35	0	1
Child aged 12-15 in HH	0	204,169	0.00	0.11	0.31	0	1
Single parenthood	66	204,169	0.03	0.04	0.19	0	1
Extended family	66	204,169	0.03	0.07	0.26	0	1
HRP Divorced / separated	639	204,169	0.31	0.11	0.31	0	1
HRP female	0	204,169	0.00	0.40	0.49	0	1
<b>Total</b>	<b>7,263</b>	<b>204,169</b>	<b>% 3.56</b>				

**9. Supplementary material for “Identifying people in poverty: a multidimensional deprivation measure of poverty for the EU”**

## S1. Why is accounting for multidimensionality important?

To examine the utility of multidimensionality, the total deprivation rate is decomposed into its dimensions, and i) the amount of people captured by only one dimension, ii) the association between dimensions, and iii) the risk profiles of the groups captured by each dimension are examined. In this respect, in Table S1, the correlations between dimensions are shown. In Table S2, the incidence rates for each dimension are presented (as a ratio to the total reference population). In Table S3, the results of four multinomial logit models are presented (details explained below).

The value of accounting for dimensionality can be shown based on three points. First, as shown in Table S1, the correlations between dimensions are reasonably high yet still not perfect. This might show that the dimensions represent different aspects of the same phenomenon of poverty while each still capture a distinct group.

**Table S1: Correlations among dimensions**

	Basic	Health	Education	Social	Poor60
Basic	1.00				
Health	0.54	1.00			
Education	0.64	0.43	1.00		
Social	0.77	0.50	0.67	1.00	
Poor60	0.44	0.28	0.44	0.49	1

Indeed and secondly, for all countries, a significant amount of people is deprived only in one dimension – again usually highest for social dimension and lowest for health or education dimension.<sup>62</sup> These people who are deprived in only one dimension might possibly not be identified in a unidimensional scale where different types of deprivations

<sup>62</sup> The high rate in the dimension of leisure and social activities depends partly on the holiday item – once it is excluded from the social dimension, the amount of captured only by basic goods dimension increases to 7%, by health to 3%, and by education to 2%, while the amount captured only by leisure and social activities dimension decreases to 8% in average in the EU.

put together and a non-zero threshold applied. Indeed, as presented in the next section of the Supplementary Material, when compared to other deprivation scales such as the 9-item basic deprivation index of Whelan and Maitre (2012), and the 13 item index of Guio et al. (2016), the proposed multidimensional deprivation measure captures an additional group of people, a significant majority of whom reports difficulties making ends meet, have income below 120% of median, and report significant financial strain.

**Table S2: Deprivation across dimensions in 25 EU countries**

Country	Basic	Health	Education	Social	Only basic	Only health	Only education	Only social
AT	0.24	0.04	0.07	0.34	0.05	0.01	0.01	0.15
BE	0.20	0.07	0.09	0.32	0.03	0.02	0.01	0.13
BG	0.87	0.33	0.37	0.82	0.06	0.01	0.00	0.03
CY	0.48	0.17	0.10	0.49	0.09	0.02	0.01	0.10
CZ	0.28	0.09	0.10	0.44	0.05	0.03	0.01	0.19
DE	0.23	0.08	0.10	0.39	0.03	0.01	0.01	0.17
DK	0.12	0.04	0.03	0.14	0.05	0.01	0.01	0.06
EE	0.35	0.10	0.11	0.55	0.05	0.01	0.01	0.22
EL	0.44	0.19	0.18	0.53	0.05	0.03	0.02	0.12
ES	0.24	0.10	0.12	0.42	0.04	0.02	0.01	0.18
FI	0.16	0.02	0.04	0.17	0.07	0.01	0.01	0.07
FR	0.26	0.10	0.08	0.37	0.05	0.02	0.01	0.14
HU	0.56	0.12	0.20	0.75	0.03	0.01	0.00	0.20
IE	0.22	0.09	0.11	0.44	0.03	0.02	0.01	0.21
IT	0.26	0.18	0.10	0.50	0.03	0.03	0.01	0.21
LT	0.55	0.10	0.16	0.67	0.07	0.01	0.00	0.17
LU	0.17	0.04	0.07	0.18	0.06	0.01	0.02	0.06
LV	0.64	0.30	0.18	0.76	0.05	0.01	0.00	0.16
NL	0.12	0.05	0.03	0.17	0.04	0.02	0.01	0.09
PL	0.45	0.14	0.20	0.68	0.03	0.01	0.01	0.22
PT	0.47	0.25	0.20	0.67	0.03	0.02	0.00	0.17
RO	0.70	0.31	0.46	0.88	0.01	0.01	0.00	0.13
SI	0.39	0.04	0.07	0.37	0.11	0.01	0.00	0.10
SK	0.41	0.13	0.17	0.61	0.05	0.03	0.01	0.21
UK	0.21	0.08	0.06	0.37	0.04	0.03	0.01	0.17
Total	0.30	0.12	0.13	0.46	0.04	0.02	0.01	0.16

Thirdly, the groups deprived in one dimension have substantively different profiles than those deprived in other dimensions in terms of their resources and needs. The results of which have been presented in Table S3, a multinomial logit model is run for each dimension to explore the profiles of people captured by each dimension. The dependent variables are categorized as not-identified, identified only in one dimension (e.g. basic) and identified in other dimensions (e.g. health, education and social). The reference category in each model is selected as “identified in other dimensions” to see how the profiles of deprived in each dimension are compared to the profiles of deprived in other dimensions. (The models are run for the whole EU sample with country fixed effects.) Same as the model applied in the main analysis, the explanatory variables are considered as the risk factors and represent either resources or needs (see Table 6 in the main text).

As shown in Table S3, for each dimension, the coefficients for many resource and need variables are statistically significant. In other words, the groups captured by one dimension significantly differ from the groups captured by other dimensions in terms of social class, education, economic well-being and various other need factors related to health, education and care. In addition, each dimension captures certain groups who are more likely to have needs in relevant dimensions. For example, the coefficients for variables that would proxy health care needs (e.g. disability or chronic health problem, or self-rated bad health in the household) are all significant and have higher effect sizes for health dimension than in others (except social dimension which shows the association between health and leisure and social activities). In other words, the households with higher health care needs are more likely to be captured by the health than in other dimensions. The households with education needs (e.g. having children in the household) are more likely to be deprived in education than in other dimensions.

**Table S3: Comparing the profiles captured by each dimension using multinomial logit models– incidence rate ratios (IRR)**

	Base outcomes = Other deprived			
	Model 1 Basic	Model 2 Health	Model 3 Education	Model 4 Social
<b>Resources</b>				
HRP Social class ( <i>ref=Salariat</i> )				
Intermediate employee	1.054	0.941	1.198***	1.223***
Small self-emp.	1.066	0.810***	1.225***	1.429***
Non-manual labor	1.054	0.938	1.468***	1.297***
Manual labor	1.217***	0.851***	1.650***	1.753***
Excluded	1.078	0.792***	1.184*	1.539***
HRP Education ( <i>ref=Third level</i> )				
Upper 2ndary	0.977	0.847***	1.169***	1.434***
Low2nd/Primary/Pre	1.033	0.831***	1.365***	1.924***
Unemployed in HH	1.685***	1.489***	1.504***	1.990***
Tenant	1.778***	1.439***	1.917***	0.937
Income ( <i>log equiv.</i> )	0.633***	0.976	0.622***	0.420***
<b>Needs</b>				
Disability in HH	1.078**	1.160***	1.122**	1.364***
Chronic health pr. In HH	1.076*	1.292***	0.917*	0.989
Bad subj. health	1.344***	1.303***	1.160***	1.743***
Child aged 0-2 in HH	1.240***	1.130**	1.491***	1.034
Child aged 3-4 in HH	1.120*	1.061	1.586***	0.974
Child aged 5-11 in HH	1.245***	1.218***	1.814***	1.184***
Child aged 12-15 in HH	1.081*	1.131**	1.557***	1.182***
Single parent household	1.297***	1.158*	1.108	1.324***
Extended family	1.019	1.089	1.154***	1.404***
HRP divorced/separated	1.229***	1.197***	1.316***	1.344***
HRP Female	1.173***	0.998	1.039	1.202***

These findings show the value of including each dimension and evaluating them separately to cover different experiences of poverty.

## **S2. A consistent poverty measure using the unadjusted proposed deprivation measure – a comparison to the consistent poverty measure of Whelan et al. (2013)**

In this section, a consistent poverty measure is constructed combining the proposed multidimensional deprivation measure with a relative income poverty measure (60% of median) and compared to the measure proposed by Maitre et al. (2013) (*MWN hereafter*) in their performance for identifying the people in poverty. For doing this, first, the agreement (and disagreement) between each measure is examined; then, the profiles of groups captured by each measure are compared based on some outcome indicators such as having difficulties making ends meet, financial strain and social class (ESEC 5).

In Table S4, headcount rates for each measure are presented for all countries. The results show that i) in average in the EU, the proposed measure identified 13% of the population while the MWN measure identifies 9% of the population, ii) the variance of the proposed compared to the Maitre measure is slightly higher (0.11 vs. 0.08), iii) the agreement between the two measure is very high and the only difference between the two measure is the additional group captured by the proposed measure. Following that, the question is whether this additional group improves the performance of a deprivation measure in identifying the people in poverty.

As shown in Table S5, among this additionally identified group, 78% report having difficulties making ends meet compared to the EU average of 56%; 48% report significant financial strain (2+ from the five item financial strain index) compared to the EU average of 33%; more than 50% of the household heads (household reference person) is either working class or never worked compared to the EU average of 40%; and only 12% of the household heads are in salariat class compared to the EU average

of 30%. Therefore, the proposed consistent poverty measure captures an additional group compared to the WMN measure; and this group is predominantly working class or never worked, and more likely to report difficulties making ends meet and financial strain.

**Table S4: Poverty rates and mismatch between the proposed and the MWN measure across EU countries**

Country	Consistent Deprived	Consistent WMN	Agreement	Only deprived	Only MWN
AT	0.09	0.06	0.95	0.03	0
BE	0.11	0.07	0.95	0.04	0
BG	0.21	0.21	0.98	0.01	0
CY	0.12	0.07	0.94	0.05	0
CZ	0.07	0.05	0.97	0.02	0
DE	0.12	0.09	0.96	0.03	0
DK	0.05	0.02	0.93	0.03	0
EE	0.17	0.09	0.92	0.08	0
EL	0.18	0.13	0.94	0.05	0
ES	0.14	0.06	0.90	0.08	0
FI	0.07	0.03	0.94	0.04	0
FR	0.10	0.07	0.96	0.03	0
HU	0.12	0.10	0.98	0.02	0
IE	0.12	0.05	0.93	0.06	0
IT	0.15	0.08	0.91	0.07	0
LT	0.18	0.14	0.95	0.04	0
LU	0.10	0.04	0.94	0.05	0
LV	0.24	0.20	0.95	0.05	0
NL	0.06	0.02	0.94	0.03	0
PL	0.16	0.11	0.94	0.05	0
PT	0.16	0.13	0.92	0.03	0
RO	0.22	0.20	0.97	0.02	0
SI	0.09	0.05	0.95	0.04	0
SK	0.10	0.07	0.97	0.03	0
UK	0.12	0.07	0.92	0.05	0
Total	0.13	0.09	0.94	0.04	0
Variance	0.11	0.08	0.06	0.04	0

**Table S5: The profiles of the group identified only by the proposed measure**

<b>Outcome indicators</b>	<b>codeprived=1   WMN= 0</b>	<b>EU average</b>
Having difficulties making ends meet	78%	56%
Financial strain (2+)	48%	33%
ESEC (among HRP)		
Salaried	11.8 %	30%
Intermediate	14.1%	18.9%
Small self-employed	21.6 %	11.2%
Non-manual labor	11.5 %	8.8%
Manual labor	31.8%	27.7%
Never worked	9.3 %	3.3 %

*Notes: The second column (codeprived=1 | WMN= 0) shows the ratios among the group identified additionally by the proposed measure.*

## **Conclusion**

This thesis focuses on the problem of error and validity in deprivation scales of the EU. Despite the proliferation of deprivation scales in both academic literature and policy circles, not enough attention has been put on their measurement performance. Yet, validity is always a matter of degree, and to identify the areas of improvement, it is necessary to examine the extent and sources of error. To do this, four papers in this thesis are concentrated on two main questions: to what extent are existing deprivation scales affected by systematic error in measurement due to some conceptual problems such as indexing, missing dimensions and threshold; and if so, what can be alternative ways to mitigate such error?

The first three papers address the first question, hence provide empirical evidence on the extent of error in deprivation scales related to the missing dimensions and threshold problems; while the fourth and last paper addresses the second question, and proposes and exemplifies an alternative concept-led approach to constructing a deprivation measure of poverty that can potentially mitigate such problems. In this conclusion chapter, the findings of each paper are summarized as well as their contributions to the academic literature and implications for policy. Lastly, I present an agenda for future research that builds on the findings of four papers.

### **1. Summary of the findings**

Paper 1 examines missing dimensions problem within deprivation scales focusing on a specific aspect of poverty – health care access. Using an alternative approach based on a partial criterion variable, the analysis aims to empirically identify Type II error in measurement within deprivation scales. The findings show that existing deprivation

scales misses specifically those people in poverty with a disability or chronic health problem as extra needs and costs for health care are not accounted in these scales. In other words, not accounting for needs in health care result in missing people experiencing poverty related to health needs dimension. These findings are robust for different deprivation scales. Although using a lower deprivation threshold (1+) seems to mitigate this problem, such practice is also likely to include other types of error (Type I) hence only provides a limited solution.

Paper 2 extends this argument to other relevant dimensions of poverty such as child and social care, and education. Using a self-reported measure of financial adequacy as a proxy for poverty, the main motivation is to identify the financial effect of having needs in health care, child care, social care and education on poverty status independent of deprivation status. The results of a dynamic correlated random-effect model indeed show that having needs in health, child or social care or education affect poverty status even after controlling for a deprivation scale. In some cases, people with multiple needs in these dimensions are as likely to be in poverty as those identified by the deprivation scale. The impact of missing dimensions on poverty status is explained either through greater expenses or reduced potential earnings (e.g. due to care responsibilities) and not by other factors that might spuriously explain this relationship such as state dependence, anticipation and psychological negativity bias. These findings are robust to different thresholds and specifications of the deprivation scale, and also applicable to a measure which combines income and deprivation measures with a union approach.

Paper 3 provides a conceptual and empirical argument on using zero as a threshold for distinguishing deprived and non-deprived based on existing deprivation scales. The main aim is to test the distinctiveness of zero deprivation which thence implies a natural

threshold for deprivation. An exploratory data analysis shows that those with zero deprivation has distinct profiles to other deprivation groups (e.g. ones, twos, ... nines) in terms of social class, income, education and health. This finding is also confirmed by a comparison of multiple count data models showing that the models that account for the distinctiveness of zeros fit the data much better than the models that evaluate zeros and counts together. Moreover, using a threshold of zero rather than two reveals better a *priori* expected i) strong social gradient in the risk of deprivation and rather weak social gradient in the level of deprivation, and ii) net effects of class and life course factors on the risk of deprivation. These findings are robust to different scales and weighting.

Paper 4 proposes a new deprivation measure of poverty and compares it with the existing EU 2020 poverty target in their performance of identifying people in poverty. Based on Townsend's relative deprivation framework, the paper conceptually derives four dimensions of poverty, namely basic goods, health, education and leisure and social activities – these dimensions are defined as the essential needs for performing social roles and participating in society; and each dimension contains different components reflecting the conditions of life required to meet these essential needs. The proposed measure then reflects this conceptual structure, and mainly includes scales for each component. Being deprived of a component means being deprived in the relevant dimension hence defines a poverty experience. Yet due to possible data problems such as cross-cultural equivalence, behavioral choices and reporting error, the proposed measure is adjusted using dual criteria of income and subjective financial strain, which removed around 50% of the group identified by the proposed measure. This concept-led, multidimensional, adjusted deprivation measure of poverty is shown to capture better people with needs and lower resources vis-à-vis the EU 2020 poverty target measure.

## **2. Contributions to the academic scholarship**

These findings have significant conceptual, empirical and methodological contributions to the current academic scholarship in poverty measurement. These contributions can be summarized for each paper separately, only the first two being considered together as they deal with the same problem.

*First two papers* deal with the missing dimensions problem and contribute to the current literature in elaborating existing concepts, providing empirical evidence on missing dimensions problem, and proposing and applying alternative methods to examine validity and error in deprivation scales. Conceptually, both papers identify certain dimensions of poverty generally neglected in a typical deprivation scale, namely health care, child care, social care and education. These dimensions are derived based on the relevant definitions of poverty and existing empirical evidence, represent the areas of life generally considered as essential for an acceptable living standard in today's EU, and also parts of the contemporary welfare state guarantee.

Empirically, both papers provide evidence on the problem of missing dimensions within deprivation scales and its consequences for the measurement of poverty. To my knowledge, these are the first empirical attempts to examine such issues and test the main methodological assumption of deprivation scales. The existing deprivation scales are constructed in a summary format on the assumption that only a few key indicators of deprivation can be adequate to identify people in poverty. The findings from Paper 1 and 2 does not support this claim. These two papers show that existing deprivation scales might be systematically missing people in poverty who have needs in health care, child care, social care and education. These missed groups, then, are likely to be, for example, those with chronic health problems or with caring responsibilities. Therefore,

an ordinary deprivation scale is not adequate to capture certain experiences of poverty related to the missing dimensions, and it is important to account for all different dimensions of poverty for a more accurate identification of poverty.

Methodologically, Paper 1 proposes an alternative approach to examine the empirical validity of deprivation scales using a partial criterion variable. Existing literature mainly uses a construct validation method which only gives relative evidence on the validity of the proposed measures. The proposed alternative method can be used to examine Type I and II error in specific aspects of poverty. In Paper 2, a subjective financial adequacy measure is used as a proxy for poverty – yet with utmost importance given to the possible bias that might arise due to the subjective nature of this variable. To overcome such biases, the analysis focused on a dynamic within-person over time analysis including an examination of the heterogeneity of effects across different personality traits. These two methods can be used to evaluate the extent and source of error in measurement for deprivation scales or other poverty measures.

*Paper 3* deals with the threshold problem and extends the current literature on poverty measurement in four distinct ways. *First*, the paper provides a strong conceptual and empirical argument on the selection of a deprivation threshold. This is a significantly understudied topic despite being critical to relevant analyses. Existing studies usually apply *ad hoc* thresholds. I show in this paper that scoring zero out of a deprivation index is a qualitatively distinct phenomenon to scoring at least one; and when deprivation is assumed as a binary concept, the most meaningful empirical distinction is between zeros and others given our theoretical expectations on socio-economic differentiation.

*Secondly*, the work demonstrates the social class gradient in deprivation. As emphasized by Goldthorpe (2010), there is a lack of evidence on whether the risk of

deprivation and poverty is socially stratified based on social class. Analysing separately for 25 EU countries, the paper points out the strong social class gradient in the risk of deprivation (which is significantly underestimated when a non-zero threshold is used) and a rather weak social class gradient in the level of deprivation (which is significantly overestimated when zeros are included into the analysis).

*Thirdly*, the paper empirically attests the conceptual difference between the risk and the level of deprivation. Commonly reported risk factors significantly explain the risk of deprivation but not the level of deprivation. This finding challenges the existing evidence showing the same determinants for both risk and level of deprivation, which is a result of neglecting the distinctiveness of zeros.

*Lastly*, albeit methodologically the most appropriate model, the count data models are applied to analyze deprivation for the first time in this paper. In the existing literature, deprivation risk is usually analyzed based on logit type models, and deprivation level is typically studied using linear models. Count data models are specifically designed for count outcomes, can account for the excess of zeros and be useful to simultaneously analyse and compare the determinants of deprivation risk and deprivation level.

*Paper 4* contributes mainly on the methodology of poverty measurement. The paper proposes and exemplifies a concept-led process of developing a measure of poverty, and provides empirical evidence on its performance of identifying people in poverty compared to the EU 2020 poverty target measure. In this concept-led method, multiple choices related to the measurement design such as identifying dimensions and thresholds are determined mainly based on the theoretical definition of poverty.

For the construction of such measure, the paper also provides a conceptual elaboration of poverty as relative deprivation. Such analysis mainly includes deriving the dimensions of poverty based on theory and existing empirical evidence. The identified dimensions are needs for i) basic goods, ii) health, iii) education, and iv) leisure and social activities. Specifying dimensions of poverty is crucial for securing an epistemological and empirical basis to the multidimensional nature of poverty (Alkire, 2002).

Accordingly, Paper 4 also presents some empirical evidence on the utility of multidimensionality in the measurement of poverty. The evidence on missing dimensions provided in the first two papers might suggest two ways to improve existing scales. One way would be to include relevant indicators from missing dimensions into a unidimensional scale, hence not changing the design of existing scales in terms of their structure. Another way could be to evaluate each dimension separately before having an overall assessment on poverty, hence a multidimensional design. The analysis presented in the supplementary material of Paper 4 shows that evaluating each dimension separately improves the accuracy of measurement as i) a significant group of people is identified only by one dimension whom would possibly be missed by the existing scales; and ii) groups captured by each dimension have distinct characteristics reflecting dimensions-specific profiles. So, Paper 4 establishes the value of multidimensionality for identifying people in poverty, both conceptually and empirically.

### **3. Policy implications**

In their recent book, Nolan and Whelan (2011) make a strong conceptual and empirical critique of the way the EU 2020 poverty target measure is constructed. This target measure combines a country-specific relative income poverty measure (60% of median), an EU-wide material deprivation measure (a nine-item scale with a threshold of 4+) and

a low work-intensity measure. Nolan and Whelan specifically emphasize the problems related to i) the value gained by the inclusion of low-work intensity measure, ii) the arbitrary character of the deprivation threshold, and iii) the specification of the deprivation scale. Alternatively, Nolan and Whelan argue, the deprivation scale can be improved by i) excluding 3-items from the original EU deprivation measure (TV, telephone and washing machine) and adding a new item (car); and ii) using a threshold of two (3+) rather than three (4+); and the low work intensity indicator can be excluded from the target measure.

Accordingly, Nolan and Whelan recommend two different poverty indicators for identifying a target population within the EU: i) an indicator which combines a country-specific relative income poverty measure and the 7-item deprivation scale with a threshold of two (3+) using a union approach; and ii) an indicator which combines a country-specific relative income poverty measure and the 7-item deprivation scale with a threshold of two (3+) using an intersection approach. The latter consistent poverty measure, they argue, is valuable to identify a subset of the more general target population which “could serve to identify a priority group as countries frame their individual contributions to meeting the overall EU target (Nolan and Whelan, 2011: 248)”.

In a similar vein, this thesis has important implications for the use of a poverty target measure in the EU. First, it is proposed here a multidimensional deprivation measure of poverty which can potentially be used as a stand-alone indicator to identify the target population. Both conceptually and empirically, a deprivation measure (with enforced criteria) can be adequate to identify people in poverty defined in relative deprivation framework. The proposed multidimensional deprivation measure captures almost all of those identified as income poor (based on a country-specific relative income poverty

measure), but those not identified by the proposed measure despite being in income poverty (around 3% of the EU, 18% of those identified as in income poverty) do not report significant financial strain. The proposed measure is also shown to perform better, compared to the existing EU poverty target measure, in capturing the people with lower needs and resources, and those living in less compared to more affluent countries.

Secondly, a consistent poverty measure can be constructed using the unadjusted multidimensional deprivation measure and a country-specific relative income poverty measure (60% median). As shown in the supplementary material of Paper 4, such consistent poverty measure, compared to those of Maître et al. (2013), captures an additional group of people who has significantly lower resources and more needs compared to the group who are not identified by both measures.

#### **4. Avenues for future research**

The thesis has focused on filling an empirical gap on the extent and sources of measurement error in deprivation scales. First three empirical papers, in that respect, are pioneers and open up a new field of examining error and validity in poverty measurement. Therefore, a natural progression of this agenda could be further research on empirically documenting the extent and sources of Type I and II errors in poverty measures. Also, the analysis in Paper 2 can be applied to multiple other EU countries in a comparative perspective. An interesting question would be whether the dimensions found to affect poverty status (after controlling for a deprivation scale) are common or different across countries with distinct welfare systems.

Another area of research that the findings of Paper 3 stimulate is the distinctiveness of zero deprivation. People with zero deprivation can be of further interest giving the rising

numbers of in-work poverty and experiences of “low-pay no-pay” cycle. Also using zero as a threshold is an intuitive idea yet with important implications in terms of the numbers identified as deprived. Then there might arise some questions about the robustness of the distinctiveness of zeros. For example, the analysis identified a distinct group yet only cross-sectionally. But how does this finding change over time? To what extent are zeros mobile? For those who fell in deprivation, how long are the spells? Who stays long at zero, who moves in deprivation? Which events trigger exit and re-entry into zero? To answer these questions, one can focus on the dynamics of non-deprived (different than the usual focus on deprived or poor) by examining spells of zeros with survival analysis.

Alongside these empirical and conceptual issues, one main focus of this thesis was on the methodology of poverty measurement. The proposed measure in Paper 4 was primarily designed for the purpose of identifying people in poverty, which can be further developed using Alkire-Foster method and constructing a poverty index that can evaluate both the incidence and intensity of poverty. Then an interesting methodological question would be to what extent the proposed measure here compares to a similar index created using Alkire-Foster method in terms of i) the groups identified as in poverty, ii) the determinants and risk profiles, and iii) country variance. In such comparison, the selected thresholds in Alkire-Foster type index are of great importance.

Yet arguably, the most pressing need for further research is in the area of data problems. The four papers here are mainly focused on the conceptual problems such as indexing, missing dimensions and threshold. However, as suggested in Paper 4, the data problems might also have a significant impact on the numbers identified as deprived, especially when a zero threshold is applied. One main concern, for example, is the very high rates in certain deprivation types (e.g. holiday) especially for less affluent

countries. The adjustment strategy in Paper 4 is removed around half of the previously identified population by the proposed deprivation measure which might be indicative of significant overestimation and across all EU countries.

Two possible sources for such error could be cross-cultural equivalence and reporting bias: i) the meaning of certain deprivation types for social participation might vary across countries; or ii) the instruments employed to capture certain deprivation types incorporate some bias. Cross-cultural equivalence can be examined within a latent variable framework following the broad literature on this topic (e.g. Davidov et al. 2014). Yet, an important constraint for such analysis is the limited number of items available for each relevant type of deprivation. An alternative method to evaluate both cross-cultural equivalence and reporting bias could be using vignettes. For example, King et al. (2004) propose an approach that focuses on directly measuring response inequivalence (across respondents) and correcting for such bias using vignettes and statistical modeling. A similar approach is recently applied by Ravallion et al. (2016) to assess scale heterogeneity in subjective economic well-being measures. Evaluating the extent of such problems in deprivation data is crucial for the validity of deprivation scales to be used as stand-alone measures of poverty for the EU.

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